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THE ELECTRON: ITS INTELLECTUAL AND SOCIAL SIGNIFICANCE[1]

By Dr. KARL T. COMPTON

PRESIDENT OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

WITHIN the past five years, centenaries, bicentenaries and tercentenaries have been much in vogue. Every town or institution or event which has claim to distinction has sought the excuse of the calendar to remind the world of its claims to greatness. Thus we have recently celebrated the centenary of Faraday's discovery of the principles of electromagnetism and the bicentenary of Watt's invention of the steam engine —discoveries which have introduced the eras of electricity and of mechanical power. The city of Chicago has reminded us that the progress of mankind really began with the founding of that community, and has led us to spend millions of dollars to gain the impression that there is really some causal relationship between Chicago and world progress. In my part of the country, the city of Boston and its suburbs staged a succession of tercentenary celebrations, as proud of their past as Chicago is of its present. Greatest of all was last summer's tercentenary celebration of Harvard University, signalizing the firm basis of intellectual freedom and leadership which is the prime requisite for a free people in a democracy.

Encouraged by the success of the Chicago Century of Progress and the Harvard Tercentenary, I venture to feature my address as signalizing an anniversary of the discovery of the electron. To be sure, it is only one generation old, and a generation is a sufficiently vague unit of time for my purposes. Yet, in spite of its youth, it bids fair to rival Chicago in its contributions to economic progress, and Harvard University in its contributions to the understanding of this world in which we live. So I venture to assert that no institu-

[1] Address of the retiring president of the American Association for the Advancement of Science, Atlantic City, evening of December 28, 1936.

tion or community, which has used one of these milestones to take stock of its achievements and plot its future course, has stronger claims to intellectual significance and practical utility than I will to-night claim for the electron.

The history of science abounds with instances when a new concept or discovery has led to tremendous advances into vast new fields of knowledge and art whose very existence had hitherto been unsuspected. The discoveries of Galileo, Faraday and Pasteur are such instances. But, to my notion, no such instance has been so dramatic as the discovery of the electron, the tiniest thing in the universe, which within one generation has transformed a stagnant science of physics, a descriptive science of chemistry and a sterile science of astronomy into dynamically developing sciences fraught with intellectual adventure, interrelating interpretations and practical values.

I take particular pleasure in mentioning these practical values, for even the most unimaginative and short-sighted, hard-headed, "practical" business man is forced to admit the justification for the pure research —of no preconceived practical use whatsoever in the minds of those who led in its prosecution and of all degrees of success and significance—which has been directed at the electron. For out of this research have come the following things which all can understand and appreciate: a growing business in manufacture of electronic devices which now amounts to fifty million dollars a year in America alone; a total business of some hundreds of millions of dollars a year which is made possible by these electronic devices; innumerable aids to health, safety and convenience, and an immense advance in our knowledge of the universe in which we live.

In science, as in human affairs, great events do not occur without a background of development. The electron had an ancestry which can be traced back through the centuries. Its immediate progenitors were the electromagnetic theory of light, spectroscopy and the leakage of electricity through gases. First cousins were x-rays and radioactivity and quantum theory, for, out of a background of long investigation of bewildering and apparently unrelated phenomena, there burst upon the scientific world the x-ray in 1895, radioactivity in 1896 and the electron in 1897—all while investigators in the older fields of heat radiation and thermodynamics were finding those bothersome inconsistencies in these hitherto respectable subjects which led to that unexpected extension of Newtonian mechanics which we now call quantum mechanics. The concept of the electron, behaving according to the laws of quantum mechanics, is now the basis of most of our interpretation of all that falls under the good old name of natural philosophy.

That only the pioneers of the scientific world were prepared for these discoveries, however, is witnessed by the fact that a standard text-book of chemistry widely used in my student days in 1904 stated that, "Atoms are the indivisible constituents of molecules," and as late as 1911 a prominent physicist warned his colleagues not to be too hasty in accepting these newfangled ideas.

The existence of electrons had been foreshadowed for a century by the facts of electrolysis which led Davy and Berzelius to conclude that chemical forces were electrical in nature, and Faraday to conclude that electrical charges exist only in multiples of some fundamental unit. For chemical acids and salts, dissolved in water, tend to split up into ions, *i.e.*, atoms or groups of atoms which move in an electric field in such directions as to indicate that they carry either positive or negative electric charges. Furthermore, it is found that the amounts of these ions which carry equal amounts of electricity are exactly proportional to the chemical combining weights of the ions. Faraday saw that this fact would be simply explained by assuming that every ion carries a charge proportional to its chemical valency, *i.e.*, the valency times a fundamental unit charge. But Faraday could not, from these facts, deduce the size of this unit of charge; he could only state the ratio of this charge to the mass of the chemical substance with which the charge was associated. Hydrogen, being the lightest of all ions, had of all known substances therefore the largest value of this ratio of charge to mass.

The first real evidence of particles of larger ratio of charge to mass than hydrogen ions came from the field of optics. Ever since Maxwell's equations of electromagnetism had predicted the existence of electromagnetic waves with the velocity of light, and Hertz, seventeen years later, had discovered them experimentally, physicists had felt sure that light must be caused by some sort of oscillations of electricity within atoms. But only the vaguest and most unsatisfactory speculations, such as whirling vortices or pulsating spheres of electricity, had been suggested.

In 1896, however, Zeeman tried the experiment of examining the spectrum of a light source placed in a strong magnetic field, and discovered that the spectrum lines thus became split into components of slightly differing wave-lengths, and that these components of the light showed characteristic types of polarization, depending on the direction in which the light emerged from the magnetic field. Almost at once, in January, 1897, Lorentz showed that this experiment proved that light is caused by the oscillation of electric charges, whose motions are affected by the magnetic field in the manner to explain Zeeman's experiments. This much was not unexpected, but what

was startling was Lorentz's proof that the Zeeman effect could only have been produced by electrified particles whose ratio of charge to mass is nearly two thousand times larger than that of a hydrogen ion, and whose mass is therefore presumably nearly two thousand times lighter than hydrogen.

Almost at once this conclusion was confirmed in a more dramatic and understandable way by J. J. Thomson, the then youthful director of the Cavendish Laboratory. But let me first pick up this thread of the story a little farther back.

All through the eighteen-eighties and early eighteen-nineties a series of most striking and unexpected discoveries followed from investigations of electric arcs, sparks and especially the glowing discharges of electricity at high voltages through glass tubes containing various gases at pressures far below atmospheric pressure. The striking color effects, mysterious luminous streamers and entirely bizarre behavior of these discharges made them the most popular, yet most elusive subject of laboratory research of those days.

It was these phenomena which led Crookes to postulate the existence of a mysterious "fourth state of matter," different from the solid, liquid or gaseous states. (Of course we now know that Crookes's fourth state is simply the ionized state of matter.)

Once, while attempting to photograph the appearance of a discharge at very low gas pressure, Crookes was bothered by the fact that all the photographic plates in the room with his apparatus became fogged, as if light-struck in spite of their opaque wrapping. He avoided the trouble subsequently, however, by keeping his new supply of plates in another room until, one at a time, they were wanted for use. Thus he solved an experimental difficulty and missed making a great discovery.

At about the same time Roentgen, in Germany, was trying the same experiment, and he too was troubled by the fogging of his photographic plates. But, as the story goes, his laboratory assistant called his attention to the peculiar fact that these fogged plates, when developed, showed the image of a bunch of keys which had accidentally been lying on top of the box of plates while the electric discharge experiments were in operation. Roentgen immediately looked into this and discovered that the fogging was due to penetrating radiations produced in the discharge tube where the cathode rays struck the target or anode. Thus by accident were x-rays discovered, that type of accident not uncommon in science when an observant experimenter is at work.

While on the subject of accidents, I might digress to tell of another accident which did not happen, also in connection with x-rays. For more than fifteen years after their discovery, disputes raged as to whether x-rays were radiations, like light but of very short wave-length, or electrically neutral particles of small mass and high speed. It was evident that they were not electrically charged, since their paths were unaffected by electric or magnetic fields. The leading advocate of the neutral particle theory was W. H. Bragg. In 1912, at Princeton, O. W. Richardson tried an experiment to see if x-rays could be refracted by a prism. A positive result would support the wave theory of x-rays. People had tried this with x-rays through glass prisms without success, but Richardson had a hunch that an iron prism might be more effective. So he passed x-rays for hours and days through the tapering edge of a Gillette safety razor blade, but without finding any refraction. If he had happened to try the edge of a crystal instead of the edge of the razor blade, he would undoubtedly have discovered the peculiar diffraction of x-rays in passing through crystals, discovered a couple of years later by Laue, Friederich and Knipping and developed by father and son, W. H. and W. L. Bragg, and which proved both the wave nature of x-rays and the atomic lattice structure of crystals. If Roentgen's discovery of x-rays was an accident, then I suppose Richardson's failure to discover diffraction of x-rays was a negative accident. I often wonder how many important negative accidents slip past us week by week!

But to get back on the subject of the electron, it was the cathode rays, which produce the x-rays, which finally turned out to be electrons traveling at high speeds. These cathode rays had been observed to shoot out in straight lines from the surfaces of cathodes in rarefied gases through which electric currents were forced by high voltage. Objects which they struck became luminous with fluorescent light, and objects in their paths cast shadows. But their true nature was disclosed when a magnet was placed near the discharge tube, for then their paths were curved in a direction showing that cathode rays were negatively charged.

By measuring this curvature produced by a magnetic field of known strength, and making a pretty sure assumption that the kinetic energy of these rays was determined by the voltage applied to the tube, J. J. Thomson in 1897 first showed that cathode rays are negatively charged particles with a ratio of charge to mass nearly two thousand times that of hydrogen. He furthermore showed that these particles are of the same type, as regards ratio of charge to mass, from whatever gas or cathode material they are produced. He therefore announced these particles, which he called "corpuscles," to be universal constituents of all substances. Thus was the electron discovered.

Quick and fast came experiments of ingenious design to study the electrons more accurately. They were pulled this way and that by electric and magnetic fields. They were caught in miniature metal fly traps,

called Faraday cages, to measure their charge and kinetic energy. They were detected in their paths electrically, or by photographic plates or by fluorescence. Continually refined from that day to this, we now know that an electron has a ratio of charge to mass which is about 1,842 times the similar ratio for a hydrogen atomic ion.

But it was very desirable to know separately the charge and the mass of an electron, and not just the ratio between these quantities. So an even more interesting lot of experiments has been carried on to measure the electron's charge. One of the papers on this week's program of the American Physical Society gives the latest results of such measurements. But they were begun back in about 1900 by J. J. Thomson and his colleagues, Townsend, H. A. Wilson and C. T. R. Wilson. I think a brief résumé of attempts to measure the electron's charge will throw an interesting sidelight on the versatility of scientific attack on a difficult problem.

The first attempts were by Townsend by measurements on the motion and electrification of fog produced when electrolytic gas was bubbled into a region of air which was slightly supersaturated with water vapor, but too many uncertainties were involved to make this work convincing. The first accepted results were by J. J. Thomson, who, after an earlier attempt, employed a technique of producing fog under controlled conditions, developed by his colleague, C. T. R. Wilson, and whose method was refined further by his pupil, H. A. Wilson.

It has long been known that water droplets of fog do not form in air which is somewhat supersaturated with water vapor unless there are nuclei, like specks of dust, on which the moisture can condense. Later Townsend found that fog will also condense on ions, and more readily on negative than on positive ions. C. T. R. Wilson designed an apparatus in which dust-free air could be supersaturated with moisture sufficiently to permit condensation of fog droplets on negative but not on positive ions, which were produced by some convenient ionizing agent. So a fog was formed, in which each droplet of water was condensed on a negative ion. Thomson employed this apparatus in the following manner.

Of course this fog gradually settled downward under the pull of gravity—slowly because the drops were small compared with the viscous resistance of the air through which they fell. It was like the slow settling of dust onto the furniture and floor of a room. But the theory of the rate at which spheres move when a force drives them through a viscous medium was already well known, due to Stokes's law. From this law, measurement of the rate of fall of the fog in centimeters per second as measured by a little telescope focused on the top edge of the fog, combined with knowledge of the force of gravity and the viscosity of air, enabled Thomson to calculate the size of the individual fog droplets. Dividing the total amount of water in the fog by the amount in one drop gave him the total number of fog droplets, and therefore the total number of negative ions. H. A. Wilson added the refinement of superposing an electric field on the gravitational field which pulled the drops through the air.

Then, as the fog settled to the bottom of the apparatus, it deposited its electric charge, which, altogether, was large enough to be measured with an electrometer. So, dividing this total charge by the number of ions composing it gave, as the charge of one ion, $3.4(10)^{-10}$ electrostatic units. This was the first real measurement of the charge of an electron, and was the value quoted in the tables of physical constants when I became a graduate student in 1910.

But about that time Millikan, who has always had a flair for picking strategically important subjects to which to devote his investigative talents, undertook with his students a revaluation of the electronic charge. Sources of error in the fog method were well recognized: fog droplets were not all the same size, though measurements could only be made on those smallest ones which fell most slowly; also droplets did not remain of constant size, smaller ones tending to evaporate and larger ones to grow; also there were unavoidable convection currents in the air which modified the rate of fall of the fog; and some droplets might contain more than one ion.

Millikan cleverly avoided or minimized these difficulties by using only a single droplet of some relatively non-volatile liquid like oil or mercury. By ionizing the surrounding air in an electric field he could put various electric charges on the drop. Illuminating it by a powerful light and viewing it like a star through a measuring telescope, he could measure its rate of fall under gravity and its rate of rise when pulled upward against gravity by an electric field, and keep repeating these observations for hours. These measurements were so precise that, to keep pace with them, he had to measure the viscosity of air with hitherto unequalled accuracy. When all this was done he had proved conclusively that all electric charges are integral multiples of a fundamental unit charge, the electron, whose value he set as $4.774(10)^{-10}$ electrostatic units, about 40 per cent. larger than the earlier estimates and believed by Millikan to be correct within one part in a thousand.

Within the past half dozen years, however, doubt has been thrown on the estimated accuracy of this value from quite a different direction, in work with x-rays. Originally x-ray diffraction experiments in crystals proved the geometric arrangement of atoms

in the crystals, but did not establish the scale of distances between atoms or the x-ray wave-length. These distances, once the arrangement of atoms was known, were calculated from absolute values of the weights of the atoms, which in turn were derived from electrochemical equivalents and the value of the electronic charge. Thus x-ray wave-lengths, masses of atoms and distances between atoms in crystals all had values dependent on knowledge of the charge of the electron.

Recently, however, A. H. Compton, Beardon and others have succeeded in making measurements of x-ray wave-lengths by diffracting x-rays from a grating ruled with 15,000 to 30,000 parallel fine lines to the inch, and operating near the angle of grazing incidence. These measurements involve only knowledge of the number of lines per inch on the grating, and the angles of incidence and diffraction of the x-rays—both depending only on measurements of length and capable of high precision. X-ray wave-lengths thus measured were a little different from the earlier accepted values, and this cast doubt on the accuracy of the electron charge value which had been used in the earlier x-ray estimates. The difference was not large, only one part in two hundred, but it meant either that experiments had not been as accurate as believed or that there was some unrecognized complicating factor.

So Millikan's work has been repeated in various laboratories with refinements, such as the use of a remarkably non-volatile oil for the drop. But the chief error was found to lie in the measurements of the viscosity of air. During the past year Kelletrop, of Uppsala, has thus published a revised "oil-drop" determination of electronic charge as $4.800(10)^{-10}$ e.s.u., which is in excellent agreement with the "x-ray" determinations. This morning Beardon has presented his own confirmation of this agreement before the American Physical Society.

It is an interesting coincidence that this best value of the electron's charge is exactly the same as the figure given by Rutherford thirty years ago, though then determined with so much less precision that not much confidence was placed in it, except as to order of magnitude. It was then known that the alpha rays from radium are helium atoms which have lost two electrons and are therefore doubly positively charged. Rutherford caught a lot of these alpha rays in a metal trap, measuring their aggregate electric charge with an electroscope, and counting them by the scintillations which they produced on striking a fluorescent screen or otherwise. Dividing the total charge by the number gave him double the electronic charge, which he thus calculated to be $4.8(10)^{-10}$ e.s.u.

Already knowing the ratio of charge to mass with high precision, this value of the charge enables us to fix the electron's mass as $9.051(10)^{-28}$ grams.

But when we speak of an electron's mass, we enter a whole new field of ideas. Some years before the discovery of electrons, J. J. Thomson had pointed out that an electrified particle will possess inertia, *i.e.*, mass, simply in virtue of its charge alone, irrespective of whether or not it has any mass of the gravitational type which we have been accustomed to think of. This "electromagnetic" mass comes about from the fact that any mechanical energy which is expended in accelerating an electric charge is transformed into the energy of the magnetic field which surrounds the electrified particle in virtue of its motion. In fact, the kinetic energy of a moving electric charge is found to be simply the energy of its magnetic field and depends only on the square of the velocity of the charge, the amount of charge and the geometrical shape of the charge.

Making the simplest possible assumptions about the shape of an electron, such as a solid sphere or a hollow spherical shell of electricity, and assuming all its mass to be of electromagnetic origin, the diameter of an electron was calculated to be of the order of $(10)^{-13}$ cm. It must be emphasized, however, that this estimate of size is not, like the charge and mass, a definite measurement, but is simply an estimate based on assumptions at least one of which is quite uncertain. For while we have both logic and experiment to back up the assumption that all the electron's mass is of this electromagnetic origin, we must confess to utter ignorance regarding the electron's shape. Indeed, some facts suggest that it may have different sizes and shapes in different environments, as in the free state or in an orbit of an atom or in the nucleus of an atom. So our estimate of $(10)^{-13}$ cm. for the size of an electron is, at best, very crude.

The idea of electromagnetic mass was strongly supported by the fact that measurements of the mass of very fast moving electrons, through measurements of the ratio of charge to mass of beta rays from radium or cathode rays in high voltage discharge tubes, showed that their mass is not really a constant thing but increases with the speed of the electron. The value of electron mass given above applies, strictly speaking, only to an electron at rest. Practically, however, it is accurate enough for practical purposes for electron speeds below about one tenth the speed of light. At this speed the electron's mass is about half of one per cent. larger than if it were at rest. At still higher speeds, the mass increases more and more rapidly, approaching infinite mass as the speed of light is approached.

These facts, experimentally determined, were shown by Abraham to be of the type expected if the entire mass of an electron is of electromagnetic origin, due entirely to its electric charge. It was this argument,

which has since received confirmation from other directions, which was the basis of the theory that all mass, *i.e.*, all matter, is electrical. However, the simple electromagnetic concepts were not quite adequate to give an accurate quantitative interpretation of these experiments, and it required the additional introduction by Lorentz of the concepts of the special theory of relativity to bring about complete interpretation of the experiments.

Just two things more do we know accurately about the properties of electrons, in addition to their charge and mass. We know that they are also tiny magnets of strength equal to the basic unit of magnetic moment generally called the Bohr magnetron. Once the electron had been discovered, it became natural to seek in it also the explanation of magnetic phenomena, since it was only necessary to assume that the electricity of an electron is whirling about an axis and the electron becomes endowed with the properties of a tiny magnet. Parsons, Webster and others examined the possibilities inherent in various assumed configurations, with interesting results. But it was only with the introduction of the quantum theory for the interpretation of atomic structure and spectra that the magnetic character of the electron has, within the last dozen years, been put on a well-established basis.

The other thing we know is perhaps the most unexpected of all the electron's properties—it behaves like a wave when it collides with other objects. Davisson and Germer discovered this in the Bell Laboratories, while examining the way in which a beam of electrons, incident on a solid surface, was scattered or reflected by it. They found, if the surface were crystalline, that the electrons were scattered just like diffracted x-rays, but that, unlike x-rays, the wave-length of an electron is not fixed but varies inversely as its speed. J. J. Thomson's son, G. P. Thomson, has made very illuminating studies of this phenomenon, which is the inverse of the Compton effect and which together have given physicists two mottoes: "Particles behave like waves and waves behave like particles" and "Here's to the electron: long may she wave." One of the triumphs of the new wave-mechanics (a brand of quantum mechanics) is that it offers a medium of explanation of these strange phenomena. But my subject of the electron is too long to let me attempt a digression on wave mechanics.

With this sketch of the electron itself before us, let us turn to some of the more important directions in which the electron has given us an interpretation of the physical universe generally. Immediately were explained the phenomena of electrolysis and of ionization generally, for ions were simply atoms or groups of atoms which had gained or lost one or more electrons. Primary chemical forces were explained as the electrostatic attraction between atomic groups which, respectively, contained an excess or a deficiency of electrons. (The more refined interpretation of chemical forces within the past half dozen years, by Pauling and Slater, has been based upon the quantum theory of atomic structure).

The three types of rays from radioactive substances were interpreted: alpha rays as helium atoms which had lost two electrons; beta rays as electrons, and gamma rays as x-ray-like radiations. In fact Becquerel showed the magnetic deflection of beta rays in the same year, 1897, that Thomson showed the magnetic deflection of cathode rays and interpreted them as electrons.

For many years two unexplained phenomena had been studied in metals. When highly heated or when illuminated by ultra-violet light, metals had been shown to emit negative electricity. It was the work of but a year, after the discovery of the electron, for J. J. Thomson and his pupils to show that both these phenomena consist in the emission of electrons. But by what mechanisms are they thus emitted? That was a question whose study has led to most important theoretical and practical consequences.

Richardson, first as a pupil of Thomson and then as a professor at Princeton in the early nineteen hundreds, developed the theory of thermionic emission of electrons, according to which the electrons are evaporated from the surface of a metal at high temperatures by a process very analogous to evaporation of molecules. The electrons are assumed to have the same distribution of kinetic energies that molecules possess at the same temperature in accordance with the principles of kinetic theory. They escape from the surface if they reach it with enough energy to take them away in spite of the attraction tending to pull the electron back into the metal. This attraction is expressed in terms of the now famous "work-function," a sort of latent heat of evaporation of electrons, which is the work that must be done to get an electron clear of the surface. With these simple assumptions, an equation was derived for the rate of emission of electricity as a function of temperature which has stood the test of perhaps as wide a range of experimentation as any other equation of physics, a range of values of more than a million-million fold in current without any detectable departure from the theory, if this is properly applied.

Richardson's measurements of the "work-functions" of various metals showed that these values run closely parallel with one of the longest known but least understood properties of metals—their contact potential properties. By contact difference of potential is meant the voltage difference between the surfaces of two metals when they are placed in contact. Richardson

found that the difference between the "work-functions" of two metals was, within the limits of accuracy of the data, the same as their contact difference of potential. He therefore proposed the theory that the contact potential property of a metal is determined simply by the work necessary to remove an electron from its surface.

As a beginning graduate student under Richardson in 1910 I was given the job of undertaking a test of this theory through experiments on the other electron-emitting phenomenon, the photoelectric effect. Einstein a few years before had proposed his famous photoelectric equation, which was a contribution to physical theory certainly comparable in importance and thus far more useful in its application than his more impressive and wider publicized general theory of relativity. According to it an electron in a metal may receive from the incident light an amount of energy proportional to the frequency of the light—to be exact, an energy equal to Planck's constant h times the frequency ν. If it escapes from the metal it must do an amount of work w to get away, so that its kinetic energy after escape from the metal would be the difference $h\nu - w$. Obviously, by measuring these kinetic energies of electrons liberated from various metals by light of various frequencies, it should be possible to find out if the "work-functions" w of different metals are indeed related to their contact differences of potential in the manner predicted by Richardson's theory.

In two papers, by me in 1911 and jointly with Richardson in 1912, it was concluded first that the contact differences of potential are related to the "work-functions" as Richardson had predicted, and second that Einstein's photoelectric equation, rather than a rival theory then under discussion, properly described the facts. Practically simultaneously with this second paper, there appeared the report of a similar verification of Einstein's equation by A. L. Hughes, then in England, though lacking the quantitative connection with contact differences of potential.

This early work was not very accurate, partly because of lack of good vacuum technique for maintaining untarnished surfaces in a vacuum, partly through lack of constant sources of ultra-violet light and partly because the ultra-violet spectrographs used to isolate the various wave-lengths of light gave a certain spectral impurity of scattered light of other wave-lengths. These sources of error were recognized but not overcome when Millikan, in 1916, made a striking advance by using doubly purified light or otherwise correcting for the effects of impurity, and secured a verification of Einstein's equation which was far more accurate than the earlier work as regards the value of Planck's constant h. In fact, Millikan's work remains to this day as one of the best determinations of this important constant. In regard to the "work-function," however, this work of Millikan's was not so successful, for, after having apparently discovered facts at variance with Richardson's interpretation of the equation and its relation to contact potentials, these differences were ultimately found to reside in faults of experimental procedure or interpretation, so that Richardson's interpretation of Einstein's equation still holds.

In both thermionic and photoelectric effects, theoretical refinements have been introduced by the recent quantum mechanics and great advances made in experimental technique. However, it is fair to say that their interpretations on the electron theory have been among the major achievements of this theory.

While we are on the subject of electricity in metals, what constitutes the phenomenon of easy flow of electricity that is the distinguishing feature of metals? J. J. Thomson at once suggested that this must be due to the existence in metals of electrons free from their parent atoms, moving freely, except for collisions, whenever an electric field was applied in the metal. The theory thus worked out was attractive, but it encountered inconsistencies. There was not even any real evidence that electricity in metals was conducted by electrons.

Then along came Tolman with one of his brilliant ideas, skilfully followed by experiment. It had earlier been suggested that, whatever are the carriers of electric current in metals, it should be possible to centrifuge them toward the periphery of a disk if this were rotated very rapidly about its axis. To be more specific, if electrons are free to move in metals and if a wire connects the center and the periphery of the rotating disk through lightly pressing brush contacts, electrons should be thrown out of the disk at its periphery and pass back into the center of the disk through the wire. It would be rather analogous to a current of water driven by a centrifugal pump through a pipe circuit. But all attempts to detect such currents proved futile, because the currents produced by the friction of the contact against the periphery were far larger than the currents to be expected from the centrifuging of electrons.

But Tolman devised two methods of giving powerful accelerations to metal conductors in such manner that he was able to measure the feeble electric currents that were produced as the carriers of electricity in the metal were shaken back and forth, and his calculations showed that these currents were indeed of the size to be expected if the current is carried by electrons. This is our direct evidence that electrons carry the electric current in metals. The mechanism by which they do this is now beginning to be disclosed by Slater, on the basis of an application of quantum mechanics and spectroscopic ideas to metals, and again is an example

of the refining power of the quantum theory to succeed where older classical theory was gropingly suggestive, but inadequate.

And now that I come to the most basic of all the phenomena which the electron has been called upon to interpret, I almost lose courage, for the subject is too vast and complex for anything but encyclopedic treatment. I refer to the structure of atoms. Previous to the discovery of the electron, literally nothing was known of the internal structure or composition of atoms. With this discovery, however, it immediately became evident that all atoms contain electrons and an equivalent amount of positive electricity in some form. It was again J. J. Thomson's genius which began the investigation of the inner atom. This was only about twenty-five years ago.

Thomson reasoned that if x-rays were made to fall on any substance the electrons in the atoms of the substance would be forced to vibrate back and forth by the powerful alternating electric forces in the x-ray waves. But, in thus vibrating back and forth, these electrons would reradiate secondary x-rays in all directions. He calculated just what fraction of the original x-ray energy ought to be thus reradiated by each electron and then set his pupils to measure just what this fraction was in specific cases. From the experimental results he was thus able to calculate the number of electrons which performed the reradiation in each case. These results indicated that the number of such acting electrons in each atom was about half the value of the chemical atomic weight of the atom. Thus first were counted the electrons in an atom.

Rutherford and his pupils, aided by the mathematical analysis of Darwin, tackled the problem from a different point of view. They studied the distribution of deflection of alpha particles, shot out of radioactive materials, as these alpha particles traversed thin sheets of solid materials. They found that this distribution was quantitatively what would be expected if the deflections were produced by ordinary electrostatic forces, varying inversely as the square of the distance, between the alpha particle and a very small object containing most of the mass in each atom. They were thus able to show that this small object was not more than one ten-thousandth of the diameter of the atom, that it contained substantially all the mass of the atom and that it carried a positive electric charge equal, in electronic units, to about half the chemical atomic weight of the atom.

Thus arose the concept that the atom is composed of a positive nucleus of small dimensions, surrounded by electrons to the number of about half the atomic weight.

This had scarcely become established when it was brilliantly refined and extended by Moseley, just before he went to his untimely death in the war in 1914. Moseley had made a most ingenious study of the spectra of x-rays of a large number of the chemical elements, using a modification of the x-ray spectroscopy technique developed by the Braggs. He found that the square roots of the frequencies of the characteristic x-ray lines were numerically very simply related to the number which gave the place of the element in the periodic table of the elements, so useful to chemists but so far entirely without explanation. Thus this number acquired a definite physical significance and is now well known as the "atomic number."

For all the elements heavier than hydrogen, this atomic number is about half the atomic weight and, to make a long story short, this atomic number turns out to be exactly the number of electronic units of charge on an atomic nucleus, or the number of electrons in the atom outside the nucleus. At the same time, Moseley's work proved to be one of the greatest advances ever made in the basic interpretive side of chemistry.

Now that the number of electrons in each atom was known, the next step was to wonder about how they were arranged, what held them in place and what they were doing in their spare time. Suggestions were not slow in coming. In fact, even before Moseley's work, two rival theories had appeared, one devised by chemist Lewis and extended by Langmuir to explain the directional symmetries of atoms as indicated by their molecular combining forms, and the other devised by physicist Bohr to account for spectra. Gradually the Bohr theory has been developed to include the symmetries of the Lewis-Langmuir theory, so that both may be said to be merged, with many major additions too numerous to mention.

It was Bohr's bold genius to cast off some of the fetters of classical mechanics, which had been pretty well proved inadequate to meet the situation, and to devise a new mechanics frankly to meet the simplest known facts of atomic structure and spectroscopy—the hydrogen atom and the atomic hydrogen spectrum. In doing so, he at one stroke brought into the same picture the quantum theory of radiation, the electronic structure of the atom and the facts of spectroscopy. He had his electron moving in a circular orbit around the nucleus under the regular laws of electrostatic attraction and centrifugal force. But he stipulated that only such orbits were possible in which the angular momentum of the electron was an integral multiple of Planck's constant h divided by 2π. And he stipulated that the electrons should not radiate energy while revolving in their orbits, but only when they jumped from one orbit to another. In this case the frequency of light radiated was equal to the change of energy of the electron between the two orbits, divided by Planck's constant h. With these assumptions, the spectra of

hydrogen and of ionized helium were quantitatively explained in their main features, but not in their finer details.

Then came the war, and we heard little of atomic structure in this country. But in Germany, Sommerfeld was extending Bohr's ideas in most interesting ways. He showed that, by considering elliptic as well as circular orbits and taking account of the variation of the electron's mass with speed, the fine details as well as the main features in the spectra of hydrogen and ionized helium were accurately explained. He also showed how the theory could be extended to deal with atoms where there were many electrons moving in orbits. He showed that these additional concepts were in the right direction to explain the more complicated spectra both in the visible and in the x-ray regions.

When this new work first was known in America, it started the most feverish and earnest scientific activity that the country has ever known and which is still in progress with undiminished zeal and with increasing productive effectiveness.

I well remember when the first copy of Sommerfeld's "Atombau und Spektrallinien" came to America in the possession of our friend, P. W. Bridgman. Until later copies arrived he knew no peace and enjoyed no privacy, for he was besieged by friends wanting to read the book, which he would not allow to go out of his possession. I recall too the sudden popularity of the only two or three men in this country who knew what a spectral series was. Heretofore practically our only interest in spectra had been in the culinary variety of spectroscopy used by chemists in identifying chemical elements. No interpretive quality to speak of had hitherto been attached to the peculiar numerical regularities which had been discovered in the vibration frequencies of groups of spectrum lines.

I recall, too, the dismay with which we found only a handful of mathematical physicists versed in the analytical dynamics underlying the new atomic structure theories. In the summer of 1921, having been taught by one of these few mathematical physicists, I went to the University of Michigan to lecture on Sommerfeld's theory, and found there also F. A. Saunders, invited to impart his knowledge of spectrum series. In the winter of 1926, Born and Jordan having just announced a new development in quantum mechanics, I found over twenty Americans in Göttingen at this fount of quantum wisdom. A year later they were at Zurich, with Schroedinger. A couple of years later Heisenberg at Leipzig and then Dirac at Cambridge held the Elijah mantle of quantum theory. In our own country contributions are coming rapidly, particularly in the fields of application to chemical interpretations, metals and other complex situations.

From all this has come the situation which permitted Dirac, a few years ago, to write: "The underlying physical laws necessary for the mathematical theory of a large part of physics and the whole of chemistry are thus completely known, and the difficulty is only that the exact application of these laws leads to equations much too complicated to be soluble." But if any ambitious young scientist be discouraged lest there be little left to do, let him consider the unexplored atomic nucleus or the fact that every attempt to apply these laws, which look so satisfactory to us now, discloses new realms of knowledge still unexplored.

Time forbids mention of the most interesting work which was done to check and extend the theories of atomic structure, through direct measurement of the energy states of atoms and molecules by carefully controlled bombardment of these molecules by electrons. Begun by Frank and Hertz in Germany, much of this work was done in America by Foote and Mohler at the Bureau of Standards, by my students at Princeton and by Tate's group at Minnesota, all since 1920. In fact, both the addresses in Section B to-morrow morning are on this subject, retiring vice-president Tate discussing "Electron Impacts in Gases" and President Richtmyer, of the Physical Society, speaking on "Multiple Ionization of Atoms."

Before leaving the interpretive triumphs of the electron, however, I can not refrain from jumping from the atom to the universe, to the interpretation of conditions on the stars. Spectra of stars had long been known, and these were interpreted as indicating that some stars consist principally of hydrogen, others of helium and others of many chemical elements like our sun. But in 1922 a young Indian physicist, Megh Nad Saha, first applied atomic structure theory and knowledge of ionizing potentials to the sun and stars. He considered ionization in the hot vapors of the stars to be like a chemical dissociation produced by heat, in which the products of dissociation are electrons and the positive ionic residues of the atoms, and in which the heats of dissociation are given by the ionizing potentials of the atoms. In this way was developed a rational quantitative interpretation of stellar spectra which has thrown enormous light on the problem of conditions of temperature, pressure and condition of the chemical elements in stars. Russell in America and Milne in England have ably applied and extended this theory.

And now, finally, I come to the last phase of my subject, the social significance of the electron. By this I mean, of course, its useful applications. The first of these was Edison's invention of a thermionic rectifier, based on his discovery that negative electricity would flow across a vacuum from a hot filament to an adjacent electrode, but would not flow in the opposite direction. This was some years before the electron

was discovered as the responsible agent in this phenomenon. But within a few years after the discovery of the electron, Fleming had shown that this same device will operate to rectify radio wave impulses, and thus permit their detection with a sensitive direct current instrument. From this was patented the Fleming valve.

Once the basic character of thermionic emission was understood, and spurred on by the opportunities opening up in the radio field, new inventions, improvements and applications of thermionic devices came rapidly. Of major importance was the three-electrode tube amplifier of De Forest. Industrial research laboratories in the communications and electric manufacturing business took the lead in developing techniques and in penetrating scientific exploration. Noteworthy were the vacuum techniques and the monomolecular layers of activating materials developed by Langmuir and the high-vacuum thermionic x-ray tube of Coolidge. In the Bell Laboratories, oxide-coated filament tubes of good performance were developed and applied particularly to use in long-distance telephony. Let me give just two illustrations of the marvelous powers of some of these instruments.

It has been calculated that the energy of a transatlantic radio signal caught by the receiving station in Newfoundland comes in at about the rate required to lift a fly seven inches in a year!

What is the largest number that has any physical significance? This is impossible to answer, being largely a matter of definition. But one common answer to this is $(10)^{110}$, or one followed by 110 ciphers. This is about the number of electrons (the smallest things known) which would be required to fill up the universe to the greatest distances discovered by astronomy, if the electrons could be imagined to be closely packed side by side to fill up this whole space. Yet this number, large as it is, is very small indeed compared with the aggregate factor by which the energy of a voice striking a telephone transmitter in San Francisco is amplified by electronic tubes in the process of a long distance telephone conversation to London. This amplification factor is about $(10)^{256}$, or unity followed by 256 ciphers. If the universe were multiplied in size by the number of times it is larger than an electron, it could still not hold as many electrons as the number of this telephone amplification factor!

Then, mostly within ten years or so, has come an active introduction of thermionic devices which are not highly evacuated, but operate with supplementary action of intense ionization of the gas in the tube. First of these were the low voltage arc rectifiers, like the Tungar. Most interesting and versatile are the thyratrons, which permit easy control of powerful currents and machinery, and which give a new means of converting alternating into direct current, or *vice versa*. In this group also are some of the new types of lamps, of high efficiency or special color.

Not so striking, but equally interesting have been the useful applications of the photoelectric effect. First was the use of sensitive photoelectric cells to replace the eye or photographic plate in astronomical telescopes. Then came sunshine meters, devices to open doors or count people or sort merchandise automatically or to register the speed and license number of the unwary autoist. Most important thus far are the current-producing mechanisms in the sound-movie apparatus and in television equipment.

While, commercially, radio, sound movies and long-distance telephony are at present of greatest importance, of no less importance, especially to us as scientists, are the marvelous tools which have been put into our hands for further research in practically every field of science, from physics and chemistry to psychology and criminology.

So we see how, within one generation, the electron has been discovered and examined, with its aid our intellectual outlook upon the universe has expanded in content and simplified in basic concept, and in its use mankind has the most versatile tool ever put to use. The end of the story is far from told. Every fact or relationship of the electron appears fuzzy with uncertainties when closely examined, for it can truly be said that every discovery discloses a dozen new problems. The field of practical and commercial uses of electronic devices is certainly still largely in its early stages of exploration.

This story illustrates in vivid manner a number of characteristics of scientific work, some of which I shall simply enumerate: (1) progress comes by spurts of advance as some big new idea opens up new territory, alternating with periods of consolidation; (2) progress comes not by revolution or discarding of past knowledge and experience, but is built upon past experience and is its natural extension once the vision from new vantage points is secured; (3) there is nothing so practical in its values as accurate knowledge, and the pursuit of such knowledge has been most successful when not fettered with the initial demand that it be directed toward practical ends.

I would not give you the impression that it is only the electron which has given new life to modern physical science. A story of similar interest could be built around the new concepts of radiation and atomic energy as expressed in the quantum theory, or about the electron's big brother, the proton, or his rather nondescript cousin, the neutron. In the atomic nucleus is a field of further exploration of enormous promise, now only beginning to be opened up by us

of radioactive materials, cyclatrons and high-voltage generators.

Although these things have happened very recently, no one has better described the process and intellectual value of this type of scientific research than did Aristotle in the quotation which is inscribed in Greek on the façade of the National Academy of Sciences Building in Washington: "The search for truth is in one way hard and in another easy, for it is evident that no one can master it fully nor miss it wholly. But each adds a little to our knowledge of Nature, and from all the facts assembled there arises a certain grandeur."

OBITUARY

THEODORE JAMES BRADLEY

ON Friday, December 11, American pharmacy was made immeasurably poorer by the death of Dr. Theodore James Bradley, dean of the Massachusetts College of Pharmacy and president of the American Association of Colleges of Pharmacy. Dean Bradley was born in Albany, New York, sixty-two years ago last August.

He was graduated from the Albany College of Pharmacy in 1895 and taught in this institution for seventeen years following graduation. He was professor of mathematics in the Albany Academy for sixteen years and taught chemistry at the Albany Medical College from 1897–1907, inclusive. In 1912 he became dean of the Massachusetts College of Pharmacy, where he would have completed his 25th year of service in June, 1937.

Under Dean Bradley's administration, the Massachusetts College of Pharmacy has enjoyed a most unusual development and growth. It is housed in one of the finest pharmacy college buildings in the United States, is well equipped and enjoys a very substantial endowment.

Dean Bradley was a member of the U. S. Pharmacopoeia X and XI Revision Committees. He acted as secretary-treasurer of the American Association of Colleges of Pharmacy from 1917 to 1922. He was a member of the American Pharmaceutical Association for forty years, an association which he served as president in 1926. In August, 1936, he was elected president of the American Association of Colleges of Pharmacy, an organization which he served long and faithfully for many years. He was a member of the American Chemical Society and various other professional and scientific organizations.

He was given the honorary master of arts degree by Union University in 1912. In 1927 the Massachusetts College of Pharmacy conferred upon him the honorary degree of doctor of pharmacy and in 1927 the Philadelphia College of Pharmacy and Science granted him the degree of master of pharmacy.

Dean Bradley was the author of two text-books which are widely used in colleges of pharmacy in this country. He has written many articles for the pharmaceutical press and has made almost innumerable addresses at national and state conventions of various pharmaceutical bodies.

Dean Bradley is survived by his widow and three children, to whom we extend heartfelt sympathy.

Dean Bradley was one of the most respected men in American pharmacy to-day. He was admired for his fundamental honesty and profound loyalty to his friends and the various worthy enterprises for which he worked during his lifetime. Pharmacy has been greatly enriched by his splendid life of sacrifice and service. His death will be deeply felt and mourned by his great host of friends in various parts of the country.

E. L.

GEORGE C. CROWE

GEORGE C. CROWE, assistant park naturalist of Yellowstone National Park, died in the Park Hospital in Livingston on October 27, after a week's illness. His body was taken to Oakland, California, for burial. Mr. Crowe, who was 47 years old, was first taken ill on October 21 and rushed to the Park Hospital. He is survived by his widow and three children—Helen, 9; Margaret, 17; Robert, 20—his mother and two sisters.

He had served the National Park Service since 1929, as junior naturalist at Yosemite National Park, custodian at Devils Tower National Monument and as junior and assistant park naturalist at Yellowstone since March, 1932. His student days were spent at the University of California, majoring in mining and geology.

On leaving college, he toured the United States lecturing on the contemplated Panama-Pacific Exposition in San Francisco. Then followed several years of service with the Boy Scouts of America. After demonstrating his ability as a nature guide in Yosemite, he joined the naturalist staff.

His enthusiasm for his work was unbounded, and his endeavor to be of service to the park visitor was conspicuous. As a result he led thousands to an intimate knowledge of the scientific features of the national parks and made countless friends for park ideals and standards. Around the evening campfire, he exhibited great ability as a leader and entertainer, but never forgot the importance of the educational opportunities which such gatherings possess. Every museum enterprise with which he was connected showed the result

of artistic ability at graphic presentation, and many were the interesting observations he recorded in park *Nature Notes*.

Mr. Crowe, with an all-round knowledge of nature and her laws and ability to arouse enthusiasm for nature study in park visitors, exemplified the highest ideals of the naturalist service, which endeavors to bring to every visitor to the national parks a maximum of knowledge and appreciation of its chief features.

George C. Crowe was known to hundreds of high-school and college students in Montana and Wyoming through his lectures on park wildlife, and he had interested himself in the past four years in the CCC enrollees in Yellowstone National Park. Acting Superintendent J. W. Emmert paid tribute to him as an "extremely faithful, conscientious, and capable employee," and the Livingston *Enterprise* said, in an editorial, "The shock brought by news of Naturalist Crowe's death caused wide grief and sadness. The National Park Service and the communities of Mammoth and Livingston can ill afford to lose such sterling character as he possessed."

H. C. BRYANT

RECENT DEATHS

DR. HENRY S. PLUMMER, professor of medicine in the Graduate Medical School of the University of Minnesota, chief of the division of medicine of the Mayo Clinic and president of the Mayo Foundation, died on January 1 at the age of sixty-two years.

PROFESSOR CHARLES WINTHROP CROCKETT, who retired two years ago as head of the department of astronomy and mathematics at the Rensselaer Polytechnic Institute, died on December 30 at the age of seventy-four years.

DR. PHILIP EMBURY BROWNING, who retired as associate professor of chemistry at Yale University in 1932, died on January 2 at the age of seventy years.

DR. THEODORE JAMES BRADLEY, since 1912 professor of chemistry and dean of the Massachusetts College of Pharmacy, died on December 11. He was sixty-two years old.

THE death at the age of sixty-five years is announced of Sir Grafton Elliot Smith, professor of anatomy in the University of London.

SIR JOHN ROBERTSON, professor of public health in the University of Birmingham, died on December 1 in his seventy-fifth year.

DR. CARL STUMPF, professor of psychology at the University of Berlin, died on December 29 at the age of eighty-eight years.

SCIENTIFIC EVENTS

THE INTERNATIONAL CONGRESS OF GENETICS

THE translation given below of an article appearing in *Izvestia*, Moscow, on December 21, 1936, has been sent to SCIENCE by the Tass Telegraph Agency of the USSR, with a request for its publication.

In connection with the postponement of the convocation of the International Genetics Congress, an American agency, *Science Service*, comes forward with a statement about the "non-existence of intellectual freedom" in the USSR, and the *New York Times* has a report of the arrests of Professors Agol and Vavilov in the USSR. We have the following to report:

First. There really does not exist in the USSR that "freedom" of genetic science which in certain states is understood as freedom to kill people or as freedom to destroy whole nations because of their alleged "inferiority."

Second. Real freedom of research, real intellectual freedom exists only in the USSR, where science works not for the benefit and the hire of a narrow group of capitalists but for the good of, and in the interest of, all peoples and of the whole of mankind. Evidence of this is shown by the public discussion on problems of genetics which is now proceeding in the sessions of the Lenin Agricultural Academy with the participation of over five hundred scientists. The allegedly arrested Professor Vavilov, as has already been announced in the Soviet press, on December 22, will deliver a report at a session of the academy criticizing the scientific views of the young scientist, Lysenko, while the latter will read a paper criticizing the anti-Darwinist character of certain of Professor Vavilov's theoretical positions. Regarding the alleged arrest of Professor Vavilov, the *New York Times* simply lied.

Third. Mr. Agol, who has nothing in common with science, has been arrested by the organs of investigation for direct connection with the Trotzkyite murderers. With such gentlemen the USSR will invariably deal similarly in the future, no matter with what sort of supposedly scientific protective flag they might attempt to hide their criminal activity against the state. There really does not exist in the USSR "freedom" for murderers or "freedom" for propaganda of terrorism.

Fourth. The Genetic Congress, previously scheduled for 1937, has been postponed for a certain time upon the request of a number of scientists who desired more time for their preparations for the congress. The only purpose of this postponement is the desire to assure the best preparation and the most extensive participation of scientists from various countries.

THE U. S. BIOLOGICAL SURVEY

IN his annual report to the Secretary of Agriculture Dr. Ira N. Gabrielson, chief of the Biological Survey, points out that the success of rebuilding wildlife

depends on close cooperation of landowners and conservation agencies.

Practical plans that will provide for wildlife needs without interfering with other desirable objectives are being furnished by the survey to federal, state and local agencies that administer land. The survey also has put into operation this year nine cooperative wildlife research and demonstration units at land-grant colleges to show landowners that it is not only desirable but also practical to consider wildlife in their land use programs.

The principal research activities during the past year included the following: Intensified investigation of waterfowl conditions and habitats; transplanting of Pacific-coast eelgrass at certain points along the Atlantic coast in an experiment to reestablish an important waterfowl food all but eradicated by disease; renewed efforts to insure preservation of wildlife habitat in areas where mosquito-control work is planned or in progress; studies of the effects of crow-waterfowl relationships on breeding grounds and efforts to determine the effects of crow control on duckling mortality, and investigation of fox depredations on quail through a study of mortality at nests and studies of the local food habits of foxes. The bureau developed a self-feeding system at the Rabbit Experiment Station in California that reduces feed costs with production of superior-quality meat and established a research center at the Wichita Mountains Wildlife Refuge in Oklahoma. Congress authorized the purchase of land in New York on which the Fur Animal Experiment Station is located.

Biologists of the survey also continued research on forest wildlife relationships and investigations of Alaskan conditions for buffalo and musk oxen. Important bird colonies not heretofore mentioned in reports or literature were discovered on some of the major islands of the Aleutian chain by a field party, including two biologists, that spent five months in studying conditions of wildlife on these islands.

The report says that more than 225,000 birds were banded by cooperators of the bureau during the year; 269 mammal specimens were added to the collection, and 305 bird specimens were acquired.

Other features of the year's work summarized by Dr. Gabrielson in the early pages of his report are as follows:

> Thirty-two small refuges were established in North Dakota on areas reserved for wildlife and water conservation by means of gratuitous easements. An allotment of $286,240 from the Works Progress Administration made it possible to develop the refuges.
>
> An act to make effective in this country a convention between the United States and Mexico for the protection of migratory birds and game animals was passed by the Congress and approved by President Roosevelt. Two investigators cooperated with Mexican authorities in the preliminary work on the treaty. Mexico has not yet ratified. The convention will become effective upon exchange of ratifications.
>
> By a cooperative arrangement with the Works Progress Administration the bureau will investigate all proposed drainage projects that may materially affect wildlife environment.
>
> The number of injurious rodents was reduced on 32,547,769 acres for the protection of farm crops, range grasses, silvicultural plantings, reclamation waterways and surface soils threatened by erosion. Rodent control was extended to Hawaii, where rats seriously interfere with pineapple and sugarcane production and menace public health as carriers of bubonic plague.

GIFT OF THE GENERAL EDUCATION BOARD TO THE MEDICAL SCHOOL OF THE UNIVERSITY OF CHICAGO

THE General Education Board of New York has given to the University of Chicago the sum of $3,000,000 to be spent for the development of the Medical School and the improvement of the university generally. This is the largest unrestricted gift ever received by the university.

President Robert M. Hutchins stated that the money presumably will be expended during the next five or six years and emphasized the necessity of undertaking within that period to replace the gift by raising additional endowment of not less than $15,000,000 for medical and general university support.

Although the trustees have absolute discretion in spending the grant, the background of the discussions leading to the gift suggested that about $360,000 a year would go to medicine. Dr. Hutchins explained that the primary interest of the General Education Board in making the grant was in medicine. The Medical School was founded in 1927 with the help of the board, which since has been making temporary grants to assist the school. The present gift is intended to continue these grants and to provide a substantial sum for improvement.

The board regarded support of the university generally as incidental to the support of the Medical School, believing it impossible to develop a strong medical school apart from a strong university because of the dependence of medical education and research on the closest possible association with good departments in the natural sciences.

In making this grant, the board made clear the fact that the gift was not to be regarded as implying the existence of any peculiar responsibility to the University of Chicago.

The following statement was made:

> We do not recognize any such responsibility, nor have our trustees ever considered that they were under any

obligation to the university that differed in any way from the obligation which they have to other institutions of similar rank.

We emphasize this point because in some quarters it has been intimated that public opinion in the Middle West and elsewhere has believed that the Rockefeller board bore a peculiar and unique relationship to the university which was not shared by other educational institutions. For the sake of the university itself, and the necessity which it faces of developing a broad basis of financial support, we would want emphatically to disavow this opinion.

Of the $360,000 a year to be devoted to medicine, $250,000 continues present grants and $110,000 probably will be used to support free beds in the university hospitals. This sum would support 46 free beds, and contribute to the educational and scientific effectiveness of the faculty of the school. The money made available for general purposes of the university probably will be used for new appointments, research, library books and salary increases.

AWARD OF THE EDISON MEDAL TO DR. ALEX DOW

DR. ALEX DOW, president of the Detroit Edison Company, has been awarded the Edison Medal for 1936 of the American Institute of Electrical Engineers "for outstanding leadership in the development of the central station industry and its service to the public." The medal, which was founded by friends and associates of the late Thomas A. Edison and is awarded annually for "meritorious achievement in electrical science, electrical engineering, or the electrical arts," will be presented to Dr. Dow during the winter convention of the institute in New York City, which will be held from January 25 to 29.

Dr. Dow was born in Glasgow, Scotland, in 1862, and although he is not a graduate of a technical school, he has received the honorary degrees of master of engineering (1911) and doctor of engineering (1924) from the University of Michigan and doctor of science (1935) from the University of Detroit.

During the period 1874–82, he was employed as junior clerk and stenographer in a railroad office and in the offices of a steamship company in Liverpool, England. In 1882 he came to the United States, and was employed in various departments of the Baltimore and Ohio Railroad Company. Later he was transferred to the Baltimore and Ohio Telegraph Company to take charge of local line and instrument maintenance, with some construction and experimental work on telephones. In 1888 he was employed by the Brush Electric Company, Cleveland, Ohio, as installation electrician in the Chicago office, becoming district engineer in that office in 1889. In 1893, he accepted the opportunity to design and supervise the construction of the original public lighting plant of the city of Detroit, and in 1896 he became vice-president and general manager of the Edison Illuminating Company of Detroit. This company was succeeded by the Detroit Edison Company in 1903, and Dr. Dow was retained as vice-president until 1913, when he was made president.

Dr. Dow became a naturalized citizen in 1895. He has been a leading pioneer in the United States in the engineering, rate making and general operation of the electric light and power utility, and is given credit for both the engineering and financial success of his enterprises. He has supervised the design and construction of several generating stations of the Detroit Edison system and he is called the father of the so-called "big" steam boiler in the United States, having installed 2,350-horsepower boilers at a time when 600- to 750-horsepower units were commonly considered large. He was the first to adopt the underfeed stoker for large installations, and much of the earlier development of this type of equipment was made in his power plants.

OFFICERS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

OFFICERS elected at the meeting of the council of the American Association on December 31 are as follows:

President: George D. Birkhoff, Harvard University.
Permanent Secretary: Forest R. Moulton, Chicago.
General Secretary: Otis W. Caldwell, Boyce Thompson Institute for Plant Research.
Treasurer: John L. Wirt, Washington.
Members of the Executive Committee: Edwin G. Conklin, Princeton University; Henry B. Ward, University of Illinois (emeritus).
Members of the Council: Vincent du Vigneaud, George Washington University; Sam F. Trelease, Columbia University.
Members of the Finance Committee: Arthur Keith, U. S. Geological Survey; Charles S. Baker, Washington.
Members of the Grants Committee: A. T. Poffenberger (Psychology), Columbia University; Jacob G. Lipman (Agriculture), New Jersey Agricultural Experiment Station.
Trustee on the Board of Science Service: J. McKeen Cattell, editor of SCIENCE.
Vice-presidents of the Association and Chairmen of the Sections:
Mathematics (A): W. D. Cairns, Oberlin College.
Physics (B): Harvey Fletcher, Bell Telephone Laboratories.
Chemistry (C): Farrington Daniels, University of Wisconsin.

Astronomy (D): Philip Fox, Adler Planetarium and Astronomical Museum.
Geology and Geography (E): Kirtley F. Mather, Harvard University.
Zoological Sciences (F): Ralph S. Lillie, University of Chicago.
Botanical Sciences (G): F. E. Denny, Boyce Thompson Institute.
Anthropology (H): John R. Swanton, U. S. Bureau of American Ethnology.
Psychology (I): A. T. Poffenberger, Columbia University.
Social and Economic Sciences (K): Stuart Rice, U. S. Bureau of the Census.
Historical and Philological Sciences (L): R. C. Archibald, Brown University.
Engineering (M): J. W. Barker, Columbia University.
Medical Sciences (N): Esmond R. Long, University of Pennsylvania.
Agriculture (O): E. C. Auchter, U. S. Bureau of Plant Industry.
Education (Q): Ralph Tyler, the Ohio State University.

Secretaries of Sections:
Mathematics (A): E. R. Hedrick, University of California at Los Angeles.
Physics (B): H. A. Barton, American Institute of Physics.
Chemistry (C): Neil E. Gordon, Central College, Fayette, Mo.
Astronomy (D): Harlan T. Stetson, Massachusetts Institute of Technology.
Geology and Geography (E): Howard Meyerhoff, Smith College.
Zoological Sciences (F): George A. Baitsell, Yale University.
Botanical Sciences (G): J. T. Buchholz, University of Illinois.
Anthropology (H): W. M. Krogman, Western Reserve University.
Psychology (I): Leonard Carmichael, University of Rochester.
Social and Economic Sciences (K): E. P. Hutchinson.
Historical and Philological Sciences (L): Joseph Mayer, Library of Congress.
Engineering (M): F. M. Feiker.
Medical Sciences (N): Malcolm Soule, University of Michigan.
Agriculture (O): M. F. Morgan, Connecticut Agricultural Experiment Station.
Education (Q): P. M. Symonds, Teachers College, Columbia University.

Members of the Sectional Committees:
Mathematics (A): M. H. Stone, Harvard University.
Physics (B): J. W. Beams, University of Virginia.
Chemistry (C): Irving Langmuir, General Electric Company.
Astronomy (D): Carl O. Lampland, Lowell Observatory.
Geology and Geography (E): Preston E. James, University of Michigan.
Zoological Sciences (F): J. H. Bodine, University of Iowa.
Botanical Sciences (G): Neil E. Stevens, U. S. Bureau of Plant Industry.
Anthropology (H): Carl Guthe, University of Michigan.
Psychology (I): E. C. Tolman, University of California.
Social and Economic Sciences (K): H. G. Moulton, Brookings Institution.
Historical and Philological Sciences (L): Max Farrand, Huntington Library.
Engineering (M): F. L. Bishop, University of Pittsburgh.
Medical Sciences (N): Paul R. Cannon, University of Chicago.
Agriculture (O): R. J. Garber, West Virginia University.
Education (Q): E. J. Ashbaugh, Miami University.

SCIENTIFIC NOTES AND NEWS

AT the meeting of the American Association for the Advancement of Science held last week at Atlantic City, Dr. George D. Birkhoff, Perkins professor of mathematics and dean of the Faculty of Arts and Sciences at Harvard University, was elected president, to succeed Dr. Edwin G. Conklin, professor emeritus of zoology at Princeton University. Dr. Forest R. Moulton, formerly professor of astronomy at the University of Chicago, was elected permanent secretary to succeed Dr. Henry B. Ward, emeritus professor of zoology in the University of Illinois. Other officers elected are given in a note under "Scientific Events." A full account of the meeting, prepared by the permanent secretary with the cooperation of the secretaries of the sections and affiliated societies, will be printed in the issue of SCIENCE for February 5.

THE annual prize of $1,000 of the American Association for the Advancement of Science for a paper containing "an outstanding contribution to science presented at the meeting" was awarded at the Atlantic City meeting to Dr. Wendell M. Stanley, of the Rockefeller Institute for Medical Research, Princeton, N. J., for his paper entitled "Chemical Studies on the Virus of Tobacco Mosaic Disease."

DR. EDMUND W. SINNOTT, professor of botany at Barnard College, Columbia University, was elected at the Atlantic City meeting president of the Botanical Society of America. He succeeds Dr. C. Stuart Gager, director of the Brooklyn Botanic Garden.

DR. CHARLES PALACHE, professor of mineralogy at Harvard University, has been elected president of the

Geological Society of America at the Cincinnati meeting. He succeeds Dr. W. C. Mendenhall, director of the U. S. Geological Survey. The vice-presidents elected are: Dr. W. O. Hotchkiss, president of the Rensselaer Polytechnic Institute, Troy, N. Y.; Dr. G. D. Harris, of Cornell University, Ithaca, N. Y.; Professor Charles P. Berkey, of Columbia University, and Professor C. R. Longwell, of Yale University.

THE Paleontological Society of America, meeting in Cincinnati on December 29, elected Dr. Joseph A. Cushman, of Sharon, Mass., to the presidency. Dr. Carey G. Croneis, of the University of Chicago, was elected vice-president, and Dr. B. F. Howell, of Princeton University, Dr. Carl C. Dunbar, of Yale University, and Dr. John B. Reeside, of the U. S. Geological Survey, were reelected secretary, treasurer and editor, respectively.

DR. NORMAN L. BOWEN, of the Geophysical Laboratory of the Carnegie Institution of Washington, was elected president of the Mineralogical Society of America, which met in Cincinnati in conjunction with the American Geological Society. Dr. Bowen succeeds Professor William S. Bayley, of the University of Illinois.

DR. WILDER PENFIELD, director of the Montreal Neurological Institute, was elected president of the Association for Research in Nervous and Mental Disease at the closing session of the New York meeting. He succeeds Dr. Walter Timme, of Columbia University. Dr. Angus M. Frantz and Dr. Clarence Hare, both of New York City, were elected secretary-treasurer and assistant secretary, respectively.

IN honor of Dr. William Albert Setchell, professor of botany at the University of California since 1895, a book of "Essays in Geobotany" written by a group of his professional associates from many parts of the world and edited by Dr. T. H. Goodspeed, of the university, has been compiled. The book includes articles by O. W. Arrhenius, E. B. Babcock, F. E. Clements, W. S. Cooper, Ludwig Diels, F. E. Fritsch, D. R. Hoagland, E. D. Merrill, Eduard Rübel and Carl Skottsberg.

AT the celebration of the eightieth birthday on December 31 of Brigadier-General David L. Brainard, U.S.A., retired, of Washington, the last survivor of Lady Franklin Bay Arctic expedition of 1881–1884, commanded by General A. W. Greely, the American Polar Society, of which General Brainard is the oldest active member, elected him its first honorary member "in recognition of his contribution to Polar exploration." He was presented with a scroll on which is inscribed a map showing the route taken by Lieutenant James B. Lockwood and himself, then a sergeant, which enabled them on May 13, 1882, to reach the then highest point north, latitude 83 degrees, 24 minutes, 30 seconds, on the northern coast of Greenland.

AT the fiftieth anniversary celebration of the founding of Newcomb College of Tulane University, the degree of doctor of science was conferred on Dr. Alice Hamilton, formerly assistant professor of industrial medicine at the Harvard University School of Medicine, now consultant for the Division of Labor Standards in the U. S. Department of Labor. Preceding the conferring of the degree Dr. Hamilton gave an address on "Industrial Poisons." Later a reception was held in her honor.

AT the annual dinner of the American Society of Animal Production given recently in Chicago, a portrait of Dr. W. C. Coffey, dean and head of the department of agriculture of the University of Minnesota, was presented to the Saddle and Sirloin Club. It will be hung in the Hall of Fame of the club. Dean Coffey was cited for his work in animal husbandry and was the guest of honor at the dinner. President L. D. Coffman was the principal speaker, and Dr. Andrew Boss, formerly vice-director of the Minnesota Agricultural Experiment Station, spoke of Dean Coffey's work at the University of Minnesota.

AFTER twenty years of active service at the University of Maryland, Professor Charles J. Pierson has retired as chairman of the department of zoology. He will continue to teach the courses in vertebrate morphology. Dr. Norman E. Phillips, associate professor of zoology, succeeds him as chairman of the department.

IN the department of pediatrics of the Long Island College of Medicine, Dr. Charles A. Weymuller has been promoted to a professorship; Dr. Lambert Krahulik has been appointed professor of clinical pediatrics; Dr. Stanley S. Lamm, Dr. Lewis A. Koch and Dr. David H. Shelling have been appointed assistant clinical professors. A professorship of child health and welfare, in the Division of Preventive Medicine and Community Health, has been established, and Dr. Carl H. Laws has been chosen as the first incumbent of this chair.

DR. L. J. NORTON, of the University of Illinois, has resumed his work as professor of agricultural economics after eighteen months' leave in order that he might serve as vice-president of the Production Credit Corporation of St. Louis.

DR. KARL MENGER, professor of mathematics at the University of Vienna, will join the permanent staff of the department of mathematics at the University of Notre Dame at the opening of the second semester.

DR. H. S. RUSE, lecturer at the University of Edinburgh, has been appointed professor of mathematics at University College, Southampton, to succeed the late Professor R. C. J. Howland.

THE title of emeritus professor of the University of London has been conferred on members of the faculty who retired at the close of the academic year as follows: Sir Grafton Elliot Smith, professor of anatomy at University College, whose death has since been announced; M. T. M. Ormsby, Chadwick professor of municipal engineering at University College; A. E. Jolliffe, professor of mathematics at King's College; Dr. W. A. Bone, professor of chemical technology at the Imperial College of Science and Technology; Dr. Alfred Fowler, professor of astrophysics at the Imperial College of Science and Technology; Dr. E. W. Macbride, professor of zoology at the Imperial College of Science and Technology; Dr. S. J. Truscott, professor of mining at the Imperial College of Science and Technology; Dr. W. W. Watts, professor of geology at the Imperial College of Science and Technology.

DR. EDWARD A. BIRGE, president emeritus of the University of Wisconsin, has been elected curator of the Wisconsin State Historical Society.

PAUL H. ALLEN has been appointed resident manager of the tropical station of the Missouri Botanical Garden at Balboa, Panama. He plans to conduct a scientific survey of plant life and to make collections.

THE new laboratory for sub-tropical and tropical diseases at Bellevue Hospital, New York City, will be under the immediate supervision of Dr. Douglas Symmers, general director of laboratories of the Department of Hospitals, and will be in charge of Dr. Harry Most, of the New York University Medical College, and of Dr. Amanda Hoff, of Columbia University, both graduates of the London School of Tropical Medicine.

DR. CARL J. WIGGERS, professor of physiology at the School of Medicine of Western Reserve University, has been granted leave of absence. He plans to make a trip around the world to visit medical schools at Cairo, Beirut, Bombay, Bangkok, Nanking, Peiping, Kyoto and Tokyo. He will sail with Mrs. Wiggers on January 23.

ACCORDING to press dispatches from Moscow, the All-Union Academy of Science has expelled two members on charges of violating the constitution by refusing to return to continue their scientific work in Russia. They are Dr. Vladimir N. Ipatyeff, director of chemical research in the laboratory of the Universal Oil Company, Chicago, and Professor Alexis E. Chichibabin, now working in a private laboratory in Paris.

DR. EDWIN P. HUBBLE, astronomer of the Mount Wilson Observatory of the Carnegie Institution of Washington, who during the past year has been Rhodes memorial lecturer at the University of Oxford, gave an illustrated lecture at the institution on January 5. He spoke on "Our Sample of the Universe."

EDWARD C. MOLINA, of the Bell Telephone Laboratories, gave an address on November 30 at the Iowa State College on "Probability in Engineering." In the evening Mr. Molina was a guest of Sigma Xi, before which he gave an address on "A Tour through the Probability Domain."

THE fourth annual lecture in the E. Starr Judd lectureship in surgery, established at the University of Minnesota by the late Dr. E. Starr Judd, will be given on February 3 by Dr. Evarts A. Graham, professor of surgery at the Washington University School of Medicine and surgeon-in-chief of the Barnes and St. Louis Children's Hospitals at St. Louis. The subject of the lecture will be "Accomplishments of Thoracic Surgery and its Present Problems."

A. I. LEVORSEN, consulting geologist of Tulsa, Okla., president of the American Association of Petroleum Geologists, 1935–36, gave during December a series of lectures under the auspices of the department of geology at the University of Kansas.

DR. MAUD SLYE, of the University of Chicago, lectured on October 5 on the results of her work on the rôle of heredity in cancer at the medical school of the University of Paris.

A LIMITED number of post-doctorate fellowships in physics (including astronomy), chemistry and mathematics will be available through the National Research Council for the academic year 1937–38. These fellowships carry stipends from $1,600 upward with certain allowances for dependents and are open to citizens (men and women) of the United States and Canada under the age of thirty-five years, for study in the United States or, under special conditions, abroad. Application for appointment to these fellowships should be filed with the secretary of the Fellowship Board in Physics, Chemistry and Mathematics, National Research Council, 2101 Constitution Avenue, Washington, D. C., before March 1.

THE late William C. Endicott, who died on November 28, provided in his will for bequests of $100,000 each to the Hunt Memorial Hospital, Danvers, Mass., and the Massachusetts Historical Society.

A GIFT of £200,000, twice as large as any single gift received during its history, has been made to the University of Leeds by Frank Parkinson, a former student. The gift is to be used for the proposed main

frontage to the university in connection with the reconstruction scheme which has been proceeding for some years. Last June Mr. Parkinson gave to the university £50,000 for the establishment of a scholarship fund which is now in operation.

A DONATION of £10,000 has been made by the Imperial Chemical Industries, Ltd., towards the erection of a new building for chemistry at the University of Glasgow.

Museum News reports that the National Zoological Park, Washington, D. C., recently opened the new wing to the bird house. The new structure, costing $100,000, is the first of the buildings to be opened under the $880,000 PWA construction program, which includes a new elephant house, a new house for apes and small mammals, and various service buildings. In the new bird wing the cages have glass fronts instead of the usual wire, and skylights which can be thrown back in fair weather to give the birds direct sunshine. Two large panorama cages occupy opposite ends of the house, one refrigerated for Arctic birds, the other for tropical birds. There is a tank for diving birds. The new wing opens into two corridors from the old bird house.

THE faculty of Rush Medical College of the University of Chicago recently voted to abolish the requirement of the fifth year for the degree of doctor of medicine, effective on December 15. Certain additional provisions were made for students who have received the four-year certificate since 1934 and who never received their degree because of illness and for students who received the certificate in the past year who were either not under contract to a hospital or whose contract could be altered by the hospital concerned to permit them to receive their degree before completing their internships.

THE Academy of Natural Sciences of Philadelphia has published the first issue of a popular magazine entitled *Frontiers*. Effingham B. Morris, president of the academy, in an introductory note states that the magazine "is addressed to all persons, old or young, who wish to increase their knowledge of the world of nature." It will appear five times a year—in October, November, January, March and May. It will be sent without extra charge to members of the academy and will also be offered for sale generally. Members of the advisory editorial committee are Cary Bok, trustee of the academy; Robert K. Enders, assistant professor of zoology at Swarthmore College; John M. Fogg, Jr., assistant professor of botany at the University of Pennsylvania; Witmer Stone, vice-president of the academy, and John H. Fulweiler, secretary.

THE *Journal* of the American Medical Association states that the association and the National Broadcasting Company are presenting the second series of dramatized health broadcasts under the title "Your Health." The first broadcast in the new series, the thirty-second dramatized cooperative broadcast under the title "Your Health," was given on October 13. The theme for 1936-1937 differs slightly from the topic in the first series, which was "medical emergencies and how they are met." The new series is built around the central idea that "100,000 American physicians in great cities and tiny villages, who are members of the American Medical Association and of county and state medical societies, stand ready, day and night, to serve American people in sickness and in health."

DISCUSSION

THE INTERRELATIONSHIP OF VITAMIN A AND GLUCURONIC ACID IN MUCINE METABOLISM

A DEFICIENCY of vitamin A is known to produce metaplastic changes in the mucous epithelium. Clinically the advent of metaplasia is noted by the presence of xerosis. As the deficiency becomes more pronounced, xerosis is followed by keratinization, and this in turn by desquamation. Washings from the conjunctival sac and urinary sediment show an increase in the number of desquamated epithelial cells, thus providing evidence that these structures are suffering from a shortage of vitamin A.

The mucosa of the gastro-intestinal tract does not provide evidence of this sort so readily. This tract is, however, exposed to more traumatic injury than any other system having a lining of mucous epithelium. We have shown by actual goblet cell counts of comparable areas of entire villi that there is a marked reduction in the number of mucus-secreting elements and an increase in the number of goblet cells showing reduced activity in vitamin A deficiency. A reduction in the amount of mucus exposes the lining of the stomach, pylorus and large intestine, especially, to injuries produced by the solid components of the food or feces. These will result in capillary bleeding, which in turn will be responsible for blood in the stools. We believe that the occurrence of occult blood in the feces is the earliest evidence obtainable of a deficiency of vitamin A.

A prosthetic portion of the mucin molecule is glycuronic acid. In vitamin A deficiency, a failure in the production of mucus can not be due to an inadequacy of protein, but it might be due to an insufficiency of glycuronic acid. There are apparently two sources of glycuronic acid available to the body, namely, endogenous sources synthesized from glycogenic amino-acids and exogenous sources present in food material. Very great importance must be attached to the exogenous sources under those conditions where the body demands glycuronic acid in larger quantities or at a faster rate than can be produced by endogenous metabolism.

In an attempt to throw further light on the mechanism of mucus production, means were instituted to deplete the glycuronic acid of experimental animals. Rabbits were placed on a diet of oatmeal and water. Three times daily, gradually increasing doses of menthol were administered by stomach tube. Menthol is conjugated with glycuronic acid, and the resulting menthol-glycuronate to a large extent is excreted in the urine. As soon as the dosage of menthol increased to the point where it demanded a larger amount of glycuronic acid than could be supplied by either exogenous or endogenous sources, signs of intoxication occurred. Animals surviving from two to four days show upon autopsy ulcerations in the stomach, pylorus, gall bladder, small and large intestine. These ulcers and erosions bear a marked resemblance to those occurring in vitamin A deficiency.

From studies of this sort, the impression has been gained in this laboratory that the fundamental cause of ulcerative and erosive changes in the gastro-intestinal mucosa is due to the presence in the body from any source whatsoever of toxins so constituted that in order for their detoxication they must be conjugated with glycuronic acid. The demands for detoxication evidently take precedence over the demands of mucin production, with the result that when there is a sufficient accumulation of toxins there will follow as sequelae erosion and ulcers in the gastro-intestinal tract. Since the conjugation of glycuronic acid and toxins occurs in the liver any impairment in hepatic function will predispose to an earlier appearance of mucosal damage. It appears that vitamin A is involved somehow in this mechanism. The evidence of Clausen[1] and others that the reserves of vitamin A or its provitamin are nearly, if not entirely, exhausted in septic diseases is not to be explained entirely on the basis of impaired absorption. The fact that it does not seem probable that all the benefit[2] enjoyed by vitamin A deficient animals when fed whole apple is due to vitamin A only is further evidence in this connection. More work is being done along this line and it is hoped that more information will be provided in the near future.

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[1] S. W. Clausen, *Jour. Am. Med. Asn.*, 101: 1384, 1933.
[2] I. A. Manville, A. S. McMinis and F. G. Chuinard, *Food Research*, 1: 121, 1936.

CONCERNING FOSSIL REMAINS OF LEGUMINOUS PLANTS

ONE feature of the symbiotic nitrogen fixation process of the *Leguminosae* which has received little attention is the possibility of finding fossil remains of these plants with patterns of root nodules. Perhaps the survival of nodules through fossilization is not likely, due to the fact that the nodules are vastly more perishable than the root. From the late Cretaceous and early Tertiary times, fossils of leguminous plants have been found but without any mention of the presence or absence of nodules. The very fact that the wide distribution of the *Leguminosae* parallels the age of great mammal development would seem to indicate that these plants have from very early times harbored the bacteria and thus have been active in the fixation of nitrogen. If plant remains with nodules could be found we would have a clue to the early soil-enriching power of these plants.

Knowledge concerning leguminous fossils with special emphasis on nodule formation would be of great interest. The authors would like to get in touch with paleobotanists who have had experience in studying these forms. It is hoped that some one in this field will report his observations.

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MORE ABOUT SCIENTIFIC ENGLISH

IN a recent note[1] Boring has pointed out that the proper use of English in scientific publications is a matter of good taste, good manners; and suggests that the verbosity and circumlocution exemplified by Urbach in a previous paper[2] are to be judged by such standards. With this point of view I agree. The purpose of English in science is to convey as clearly as possible facts and ideas from author to reader. The trouble with such a criterion is that it implies a certain level of taste which is obviously rather rare. If the literary taste of scientists were well developed, notes on scientific English would not be written.

Scientific phraseology has, however, become so stereotyped that it is possible to single out for general attention and abhorrence specific and often re-

[1] SCIENCE, 84: 457–459, 1936.
[2] *Ibid.*, 390–391.

peated crimes against good English. Run your eye down a page or two of scientific writing and observe the recurrence of "thus." Strike it out everywhere, or almost everywhere, and notice the improvement. It is as if the writer is afraid that the connection of his ideas is not plain, and so "thuses" his way laboriously from sentence to sentence. Even commoner is "case." If you examine our current works on biology, you will find that they deal not with plants or animals but with their "cases." You will read that "in the case of Rhizopus the mycelium is aseptate," which means presumably that "the mycelium of Rhizopus is aseptate." A case is really a chance or event (aside from its specialized legal and medical uses), and is rarely needed in the sentences where it occurs. It may be entirely eliminated, or replaced by "organism," "species," "experiment" or whatever was really meant. Such a lack of precision and organization of thought is pardonable in rapid speech, but regrettable in writing.

Aside from the matter of taste, there are certain rules of grammar and syntax which, after all, deserve some respect. That clumsy and ubiquitous phrase quoted by Urbach, "due to the fact that," is not only verbose but, as commonly used, ungrammatical; "due" is not a conjunction. Why these five words should replace, incorrectly, the single perfectly respectable word "because" is a mystery, except perhaps to the journalists who invented the trick.

It is somewhat invidious to quote the mistakes of others, but a sentence like the following (which is not exceptional) illustrates the reality and the seriousness of the need for some attention to English: (The individual) "may disappear wholly from the community, as in *the case of the chestnut, due to blight,* though *this* is relatively rare." (Italics are mine.) The "case of a chestnut" should be the spiny fruit, though it is difficult to conceive how it can be "due to blight." Whether blight, chestnuts or the disappearance of chestnuts is rare is left to the imagination—or taste—of the reader.

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SCIENTIFIC BOOKS

THE PAPERS OF SIR WILLIAM HARDY

Collected Scientific Papers of Sir William Bate Hardy. Published under the auspices of the Colloid Committee of the Faraday Society. Cambridge University Press, 1936. 922 pp. $18.00.

THE "Collected Scientific Papers of Sir William Bate Hardy" are especially important for an era in which subjects for scientific research tend more and more to be determined by administrators or their committees and less and less by the unhampered imagination of the scientist. Sir William Hardy's first paper in 1891 was "On some Points in the Histology and Development of *Myriothela phrygia.*" In his last papers in 1933–34 he was still concerned with the problems of biology. Meanwhile, interested in systems characteristic of living matter, he concerned himself first with the chemistry of the proteins, then with the physical properties of films and of the boundary state. Although constantly employing the methods of physics and chemistry he was never an "applied scientist." Rather his inquisitive mind found new fields for exact investigation at the interface between biology, physics and chemistry.

Biologists often require for the solution of their problems a physics and a chemistry which has not yet been completely developed. As a consequence not only are advances made as a result of applications of physics and chemistry to biology, but biologists contribute innumerable new concepts, substances and principles to physics and chemistry. Often a Helmholtz or a Hardy contributes first to physiology and then to physics.

The first ten of the collected scientific papers of Sir William Hardy are concerned with morphology. The eleventh published in 1894 was a "Note on the Oxidising Powers of different Regions of the Spectrum in Relation to the Bactericidal Action of Light and Air." The bactericidal action of light having been demonstrated to be the peculiar property of light of short wave-length, Hardy characteristically investigated the relation of this phenomenon to the presence of some oxidizing substance acted upon by the blue and violet portion of the spectrum. For Hardy an observation was always a stimulus to the investigation of the underlying mechanism.

In 1899 appeared the last of the morphological papers: "On the Structure of Cell Protoplasm." Precisely because he was trained as a morphologist Hardy was in an admirable position to conclude "that the various fixing reagents are coagulants of organic colloids and that they produce precipitates which have a certain figure or structure" (p. 250). "Reagents which have any action at all confer a structure upon the colloidal matter which differs in most cases in kind, in some cases in degree, from the initial structure. Hence it is inferred that the structure seen in cells after fixation is due to an unknown extent to the action of the fixing reagents" (p. 291–292).

The conclusion that the structure of the living cell could only be deduced from the structure of dead mat-

ter if one knew not only the influence of the chemical reagents employed by the histologist but also the "coagulation (clotting) phenomena of death, as well as . . . post mortem change" (p. 292) led Hardy to turn his attention to the phenomena of coagulation and especially to those molecules of the body that are most readily coagulated: the proteins. In 1899 the transition is made from histology to chemistry. The next fourteen papers, appearing over the period ending in 1912, are concerned largely with colloidal solutions, especially with proteins.

The first paper of this series "On the Coagulation of Proteid by Electricity" in 1899 is a classic. With clarity and insight Hardy correctly interpreted the scattered information in the literature regarding the charged condition of matter and correctly deduced the amphoteric properties of the proteins. He noted that "Under the influence of a constant current the particles of proteid in a boiled solution of egg-white move with the negative stream if the reaction of the fluid is alkaline; with the positive stream if the reaction is acid" (p. 307). All subsequent work upon this important class of molecules follows from this observation. The work started in 1899 led to several remarkable papers, two of which on globulins appeared in 1905, one in the *Journal of Physiology*, the other as the Croonian Lecture of the Royal Society of that year. "Globulins are a class of proteids which occur in both animal and vegetable tissues. They are peculiar in the complexity of their relations to electrolytes. Insoluble in water, they are soluble in low concentrations of acids, alkalis, or neutral salts. In presence of acids the globulin is electro-positive, in presence of alkalis it is electro-negative, in presence of neutral salts it is electrically neutral. . . . The problem I propose to consider is their diversified relation to electrolytes" (p. 430).

These papers teem with incisive original observations which, however much they have been amplified in the last 30 years, have not in any important sense required reinterpretation. In them are to be found the concept of the isoelectric point and of the stoichiometric relations of proteins to acids and bases, deduced from measurements of conductivity, viscosity and electric transport of globulin ions, and the relations of the various ionic states of globulin, as well as of neutral globulin, to neutral salts.

The development of a theoretical understanding of the behavior of globulins in well-defined systems did not however replace his interest in the state of protein in nature. "The proteids of serum are electrically inactive. Neither the whole nor any fraction moves in a field. It is not possible to detect a trace of "ionic" proteid. Dialysis or dilution disturbs the equilibrium, and "ionic" globulin appears" (p. 418). "The probability of globulin being formed owing to the decomposition of a complex proteid present in serum is urged" (p. 426). However far from his morphological interests his studies of colloidal solutions seemed to take him, he was always concerned in his study of globulins with the problem of the state of matter in nature.

The study of the movement of proteins in an electric field led many biologists to investigate "the movement of free living cells suspended in a fluid through which an electric current is passing" (p. 490). The results reported on cells were as conflicting in 1911 as were those on molecules in 1899 and Hardy felt impelled to caution that "the movement of living cells, or indeed of any suspended particles, in films of liquid a millimeter or less in depth enclosed between glass plates is not open to simple interpretation" (p. 490). By 1911 Hardy's grasp of the chemical and physical problems as they related to the charged condition of matter had reached a point where he perceived the implications of the electrical density at interfaces and of the dimensions of molecules and surface layers.

In 1911 therefore, as in 1899, Hardy again changed the nature of his investigations. His work from this time on is for the most part concerned with the physical properties of matter at interfaces. Although his interest remains that of the biologist, as is attested by his papers on "Some Problems of Living Matter," "Living Matter" and "Molecular Orientation in Living Matter," he investigated such problems as "The Influence of Chemical Constitution upon Interfacial Tension," "The Spreading of Fluids on Glass," "Boundary Lubrication," "Chemistry at Interface" and "Problems of the Boundary State."

At each level of his understanding Hardy reverted to his primary interest, and the last of the collected papers is "To Remind: a Biological Essay." In this interesting lecture he warns against certain tendencies in modern science. His words have the wisdom always associated with him by his colleagues, but more important is the example he set by his scientific life. His collected writings, beautifully published under the auspices of the Colloid Committee of the Faraday Society, are a lasting memorial to him, and for us the detailed "history of a mind" such as is not likely often to appear in our times.

EDWIN J. COHN

HARVARD MEDICAL SCHOOL

VASCULAR PLANTS

Morphology of Vascular Plants; Lower Groups. By ARTHUR J. EAMES. McGraw-Hill. 1936. $4.00.

A NEW understanding of the comparative anatomy and morphology of vascular plants is one of the more recent developments in the progress of botany. Unlike the highest animal group, the vertebrates, in which

the comparative body plan has been appreciated for hundreds if not thousands of years, in the highest plant group there has been no ready key to the comparative unity of structure.

In Professor Eames's book, we have an important contribution to the general understanding of the comparative anatomy and phylogeny of vascular plants. It sums up the findings and conclusions of anatomical and paleobotanical research, a considerable part of which has been contributed during the past thirty-odd years. Several basic conclusions are presented which, if finally validated, will displace general concepts of long standing. These may be noted as follows:

(1) Vascular plants are all grouped together in one phylum, the Tracheophyta. The current division into two phyla, Pteridophyta and Spermatophyta, goes the way of the earlier separation into Cryptogamia and Phanerogamia. The seed habit is recognized as having arisen independently in more than one line of vascular type.

(2) The phylum of tracheophytes is divided into four main groups, largely on the basis of stelar and foliar differences. E. C. Jeffrey was the first to propose a division on this basis, in 1901. He divided vascular plants into two main groups, the Lycopsida and the Pteropsida. The Pteropsida comprised all true ferns and the higher seed plants, all those with large leaves which leave a gap in the vascular cylinder at the point of origin.

In the Lycopsida, he grouped the remaining vascular plants, based on a simpler stelar structure and the absence of foliar gaps. Subsequent workers have split Jeffrey's Lycopsida into three groups; the Lycopsida proper, taking in Lycopodium, Selaginella and similar fossil types; the Sphenopsida, including modern Equisetum and the Paleozoic sphenophyls; and the Psilopsida, with living Psilotum and Tmesipteris and similar Paleozoic forms.

(3) The archetypal vascular plant body is not to be considered as consisting of the three parts, root, stem and leaf. Instead, based on some rather recent paleobotanical work which has reported the structure of Silurian fossils, it is concluded that the primitive, terrestrial, vascular plant had a dichotomously branching axis, partly hypogean, partly epigean, bearing sporangia, but without leaf or root differentiation. Psilotum and Tmesipteris are the modern representatives of this plant form. Psilophyton, Rhynia were among the earliest pre-Carboniferous types.

(4) The long-standing controversy regarding the homologous or antithetic origin of alternation of generations is considered settled in favor of the former principle. The vascular sporophyte has not been derived by the progressive sterilization of a diploid sporangium, but rather by the gradual modification of a thalloid branch system.

(5) Finally, as a corollary of the preceding point, leaves of tracheophytes are recognized as having had two different origins. Those of the lycopsid type are regarded as enations; those of the larger sort, which leave gaps in the stele, are considered to have come from branch systems, become lateral and secondary by sympodial development. The dichotomy of fern venation would represent the persistence of a primitive branch condition.

All these several conclusions sum up into one broader concept, *viz.*, that vascular plants were originally derived directly from some thallophyte ancestor, and not by way of an intermediate bryophyte stage. The latter would constitute a separate line of terrestrial development from the algae.

Not all botanists will be ready to accept these conclusions. Not only will there be delay, due to natural conservatism, and to the difficulty of effecting so radical a change in thought from what has come to be familiar and traditional. Some botanists will prefer the antithetic theory of alternation and possible liverwort ancestry for vascular plants, a view so long and ably upheld by Campbell and Bower. Thus, Brown, in a recent and excellent elementary text in botany (Ginn, 1936), reaches the conclusion that "the structure of the Psilophytales fits in very well with the long-accepted idea that the Pteridophyta are derived from the Bryophyta."

On the other hand, the newer point of view has found expression in the general texts of Torrey (1930) and Sinnott (1935). In Germany, Zimmerman's "Die Phylogenie der Pflanzen" is even more comprehensive than the Eames.

R. C. BENEDICT

BROOKLYN COLLEGE AND
BROOKLYN BOTANIC GARDEN

THE NATIONAL ACADEMY OF SCIENCES. II

ABSTRACTS OF PAPERS PRESENTED AT THE CHICAGO MEETING

A comparison of differential heats of dilution with the predictions of the theory of Debye and Hückel: T. F. YOUNG (introduced by W. D. Harkins). Differential heats of dilution to be used in combination with cryoscopic measurements for the evaluation of activity coefficients of sodium chloride, in aqueous solution, have recently been determined. Significant discrepancies were encountered when the new measurements were compared with published differential heat of dilution data derived from experiments with extremely dilute solutions. Those data were also in conflict with the Debye-Hückel theory which permits a theoretical calculation of

the limit, as the molality approaches zero, of the derivative of the apparent molal heat content with respect to the square root of the molality. Both discrepancies proved to be due to calculations based upon an unjustified assumption, and both disappeared when adequate mathematical methods were applied to the calculation of the derivative. The same methods have now been applied to existing measurements of the heats of dilution of solutions of the halides, halates, nitrates and sulfates of the alkali metals. The new estimates of the limits of the derivative are in good agreement with theory. In nearly as good agreement are the values of the limiting derivatives calculated for the halides and nitrates of the alkaline earth metals. The very satisfactory agreement with theory of the behavior of a large number of electrolytes is in striking contrast with the behavior of a few, whose derivatives rise with decreasing molality, to values much larger than theory predicts. These include sulfuric acid, and the sulfates of calcium, magnesium, copper, zinc and cadmium. The sulfuric acid data can be explained by an increasing dissociation of the bisulfate ion with decreasing concentration. To be consistent with this explanation, the derivative curve should possess a maximum, the position of which is dependent upon the dissociation constant of the bisulfate ion. There is, at present, some evidence that such a maximum actually exists in the derivative curve of calcium sulfate.

Configuration changes in the reactions of complex inorganic compounds: JOHN C. BAILAR, JR., E. H. HUFFMAN and A. R. WREATH (introduced by William A. Noyes). Compounds of the octahedral configuration $[Men_2A_2]$ and $[Men_2AB]$ ("M" represents a metal, "en," ethylenediamine and "A" and "B," singly coordinated groups) can exist in *trans* forms and in optically active *cis* forms. In the replacement of A and B by other groups, there can be configuration changes in the cis-trans sense, as well as changes from one cis configuration to the other. This type of reaction is being studied in the author's laboratory in the hope of throwing some light upon the mechanism of the Walden inversion. The current theories of the Walden Inversion are based upon the behavior of organic substances and can not explain the cases under discussion. The reaction *levo* $[Coen_2Cl_2]Cl \rightarrow$ *levo* or *dextro* $[Coen_2(NH_3)_2]Cl_3$ goes through the intermediate $[Coen_2Cl(NH_3)]Cl_2$. It has been shown that the inversion does not take place in the second step. The first step is now under investigation. The coordinated chlorine groups of $[Coen_2Cl_2]Cl$ have been replaced by several other groups under a variety of conditions. In only two cases has it been demonstrated that optical inversion takes place, but it may have taken place in others. Some reactions of the chromium compound $[Cren_2Cl_2]Cl$ have also been investigated. The coordinated chlorine groups are not readily replaced, and no inversion could be demonstrated.

Catalytic effect of ammonium salts on the ammonolysis of diethylmalonate in liquid ammonia: L. F. AUDRIETH and C. SLOBUTSKY (introduced by William A. Noyes). Solutions of ammonium salts in liquid ammonia have been shown to possess the characteristic chemical properties of acids. Just as acids exert a catalytic effect upon hydrolytic reactions, so it was to have been expected that ammonium salts would influence ammonolytic reactions, that is, reactions involving the action of ammonia as solvent upon dissolved solutes. The authors have shown that the ammonolysis of diethylmalonate is markedly catalyzed by the presence of ammonium salts. This effect is a function of the concentration of the catalyst. Equivalent concentrations of various ammonium salts exert the same catalytic effect.

Distribution of chromosomal prime types in Datura stramonium: A. F. BLAKESLEE, A. D. BERGNER and A. G. AVERY.

The effect of dehydration on the exchange of salt and water between muscle and blood: LILLIAN EICHELBERGER (introduced by H. G. Wells). Experiments on normal dogs are described in which the extra- and intracellular phases of muscle were studied following (1) intravenous injection of hypertonic sodium chloride or sucrose and (2) intraperitoneal injection of (a) isotonic glucose or (b) sucrose or (c) hypertonic sodium chloride. From these data the following conclusions have been drawn: (1) Following the injection of hypertonic solutions, either intravenously or intraperitoneally, the original kilogram of muscle decreased in volume with an increase in the extracellular phase and a marked shrinking of the muscle cells. The maximum shrinkage occurred immediately following the intravenous injections. (2) For four hours following the intraperitoneal injection of isotonic glucose or sucrose the original kilogram of muscle decreased in volume. Both the extra- and intracellular phases lost water during this period of time.

Plasmapheresis, plasma exudation and traumatic shock: HENRY N. HARKINS (introduced by W. D. Harkins). Aside from nervous and toxic factors, a loss of actual fluid from the circulating blood stream has been found in certain types of shock. In some instances this fluid loss consists in whole blood, but in others it more nearly resembles blood plasma. Discussion is made of the quantitative relationship between the amount of blood lost during fatal hemorrhage, the amount of plasma lost during plasmapheresis and the amount of plasma-like fluid that exudes from the blood vessels in certain types of shock.

Respiratory phenomena in a case of dementia praecox: S. SLIGHT (introduced by H. G. Wells).

The nature of disease resistance in plants: F. C. WALKER (introduced by L. R. Jones).

The mechanism of immunity to Nippostrongylus muris, the intestinal nematode of the rat: W. H. TALIAFERRO and M. P. SARLES (introduced by F. R. Lillie). Although acquired immunity has been shown to develop following infection with *Nippostrongylus muris* by many investigators, evidence as to the mechanism of this immunity has been meager. We have found that acquired immunity to this parasite has to a large extent an antibody basis, since

it is passively transferable. Moreover, in the actively immune rat, there is a more rapid and intense inflammatory response than in the normal animal. Thus, the infective larvae attempt their usual migration from the skin to the intestines via the lung in the immune animal, but become coiled up and immobilized, probably because of the presence of antibody, within the first few hours after they reach the skin and the lungs, and become the center of an inflammatory reaction which consists mainly of eosinophils and hypertrophying agranulocytes of hematogenous origin. Such worm-nodules increase steadily in size by the addition of cells at their periphery, within which the parasites eventually disintegrate and are phagocytosed. At later stages, the worm-nodules become tubercle-like masses of cells with a precipitate around the anterior end of the worm. Some of the worms are able to escape from the nodules of the skin and lungs before this occurs, but although they migrate to the intestine of the rat, are mostly passed from the intestine without developing to maturity or laying eggs. So far the only difference we have found in the intestine between normal and immune animals is a great increase of connective-tissue basophils and eosinophils in the *lamina propria* in immune animals, the significance of which is not evident. In the skin and lungs of immune animals, there is, therefore, evidence of antibody action (immobilization of worms and formation of precipitate in and at ends of larvae) and a mobilization of host-cells which eventually remove the disintegrated worms. In the intestine, there is also evidence of antibody action (stunted growth) and mobilization of host-cells, but the exact function of the latter is obscure.

Immunogenetic studies on species relationships: M. R. IRWIN and L. J. COLE (introduced by Ludvig Hektoen). Studies from this laboratory have shown (a) that there are hereditary biochemical characters in the red blood cells of a species which distinguish its cells from those of any other species, and (b) that such characters are separable in the cells of backcross offspring from hybrids between the two species. This shows that these genetic differences between species are of the same order as those within a species. There appears to be a correlation between the presence of these species-specific characters and the amount of fertility displayed by the backcross offspring. It is possible by an extension of these methods to analyze for a species the extent to which its specific cellular characters are shared with other species. Eventually this should provide an assay of the phylogenetic relationships between species.

The relative susceptibility of the mammalian fetus to infectious agents: ORAM C. WOOLPERT and N. PAUL HUDSON. A study of the immunologic state of the adult animal is complicated particularly by two circumstances: (1) the immunologic make-up of the adult has been conditioned by countless past contacts with antigenic substances; (2) the adult is exposed during experimentation to a variety of potentially infectious and immunizing agents. The mammalian fetus, on the other hand, has had little contact with infection and occupies a sterile environment. Therefore, if responsive to infectious agents, it should offer conditions highly suitable for the investigation of certain immunologic problems. In pursuing this concept, a group of us has been studying the susceptibility of guinea pig and rabbit fetuses to parasites directly inoculated, particularly *Mycobacterium tuberculosis, Actinomyces bovis* and the viruses of vaccinia, herpes, poliomyelitis and the submaxillary gland disease of guinea pigs. The observations made in these studies were: (1) Whenever the adult of the host species was at all responsive to the particular agent, the fetus was usually much more susceptible. (2) Younger fetuses appeared to be more susceptible than older fetuses. (3) Fetal reactions to a particular parasite resembled those of the adult with respect to incubation period, organs affected, appearance of cellular inclusions, etc. However, the reaction in the fetus was often more acute and the pathologic changes more widely spread. (4) The infective agents, with certain exceptions, were not altered in their biologic properties by fetal passage. The basis for the low resistance of the fetus as compared with the adult may be due in part to (a) absence of humoral antibodies because of lack of previous exposure, (b) deficient cellular reactivity early in fetal life, (c) the possible presence of enzymatic or other substances associated with rapidly growing embryonic tissue, which may favor parasitization.

Transformation of organic designs: paleontologic aspects of organic evolution: WILLIAM KING GREGORY.

Problems in the chemistry of boron hydrides as illustrated by the newly discovered compounds B_2H_7N and BH_3CO: H. I. SCHLESINGER and A. B. BURG (introduced by W. D. Harkins). The aim of the investigations of the hydrides of boron, of which the present paper is a part, is twofold: (1) to aid in establishing structural formulae which will clarify the abnormal valence relations exhibited by boranes, and (2) to determine whether normal boron hydrides (*e. g.*, BH_3 or B_2H_4) are capable of existence. The work herein reported illustrates the type of approach employed in each problem. The new compound B_2H_7N is prepared and characterized. Its properties, particularly the fact that it takes up only one mole of ammonia instead of two to form a stable compound, are not those of an amine of diborane, $B_2H_5NH_2$. Two formulae

$$\left[\begin{matrix} H & H \\ \cdot\cdot & \cdot\cdot \\ H:B::B:NH_2 \end{matrix}\right]^{+} -H^{+} \quad \text{or} \quad \left[\begin{matrix} & H & H & \\ & \cdot\cdot & \cdot\cdot & \\ (H:B:B:NH_2)^{-} \\ & \ddot{H} & & \end{matrix}\right]$$

are suggested, and their bearing on the valence problem of diborane is discussed. By the reversible action of carbon monoxide on diborane, the new compound $BH_3 \cdot CO$ is obtained. It is shown to react with trimethylamine to form carbon monoxide and another new compound $BH_3 \cdot N(CH_3)_3$. These reactions and other properties of the compounds suggest that they are complexes containing hitherto unknown monoborine. On the other hand, the compound $BH_3 \cdot CO$ reacts with ammonia, not to liberate carbon monoxide and form $BH_3 \cdot NH_3$, but to add two moles of ammonia without loss of carbon monoxide. It is expected that further study of these substances will lead to an understanding of the relations between monoborine (BH_3) and diborane (B_2H_6).

A new method of determining the ring structures of glycosides: C. S. HUDSON and ERNEST L. JACKSON. The oxidation of several methyl glycosides has been found to yield crystalline salts of several derivatives of di-glycolic acid, the structures of which have been determined. These structures show in turn the ring structures of the parent glycosides. By this method the ring structures of the alpha form of methyl glucoside, methyl mannoside, methyl galactoside, methyl guloside and the alpha and beta forms of methyl arabinoside and methyl xyloside are shown to be of the pyranose type. A new crystalline methyl arabinoside has similarly been shown to be of the furanose type and of the alpha configuration.

A new and problematical cat-like fossil from the Eocene: W. B. SCOTT.

Contribution to the knowledge of Pleistocene vegetation in Minnesota: C. O. ROSENDAHL (introduced by A. J. Carlson). The occurrence of plant remains of Pleistocene age have been reported from 35 counties in Minnesota. A majority of the 65 recorded stations are located in the southern and western parts of the state and are distributed from near the eastern edge of the drift to the Canadian border in the Red River valley. A good deal of the plant material discovered prior to 1920 came from wells, being found at depths ranging from 10 to 195 feet, and only tentatively identified as oak, elm, cedar, tamarack or sticks, leaves and peat. Nearly all the material obtained recently, with one notable exception, has been found in road cuts or other deep excavations incident to industrial activities. Most of it is wood, in a fair to excellent state of preservation, occurring in the Nebraskan till and therefore either of preglacial or Aftonian interglacial age. There is a great preponderance of white and black spruce in the wood from the Nebraskan till, but several species of Dicotyledons are also represented. The richest deposit of Pleistocene plants in Minnesota has come from a deep well in Kittson County in the bed of Glacial Lake Agassiz. At a depth of 88 feet, and at the bottom of the Late Wisconsin till, a layer of ancient vegetation was struck that has yielded pieces of lignite, charcoal, innumerable pieces of wood, mosses, cones and nearly 600 fruits and seeds of Angiosperms. From this material there have been identified 6 genera of mosses, 4 conifers and 38 species of Monocotyledons and Dicotyledons. Many of the pieces of wood show a striking coincidence in the greatly reduced width of the annual rings towards the periphery of the stems. Very short growing seasons are indicated for the last 20 years of the life of the trees.

Paleobotanical research at the University of Chicago: A. C. NOÉ (introduced by F. R. Lillie). Paleobotanical research at the University of Chicago was established in the year 1921. It has developed along two distinct lines: a morphologic study of fossil plant structure and an investigation of fossil plant deposits with reference to problems of floral evolution, paleoclimatology and paleogeography. In recent years the field of our fossil plant exploration has been extended to distant regions in the United States and Mexico and much new structural material has been discovered.

Pre-glacial plant relics in the driftless area: NORMAN C. FASSETT (introduced by L. R. Jones). The Driftless Area, not invaded at any time by the Pleistocene glaciation, is entirely surrounded by glaciated territory. The flora of the glaciated regions is of course entirely postglacial, derived for the most part from survivors south of the glacial margin. But there is evidence that in spite of proximity of the ice some species continued to exist in the Driftless Area throughout the Wisconsin glaciations if not during all the Pleistocene. Thus we find *Montia Chamissoi* ranging from Alaska to New Mexico, with two isolated stations a thousand miles to the east in the Driftless Area. We see *Sullivantia Sullivantii* existing to-day just south of the glacial territory from Missouri to Ohio, and also in the Driftless Area, having obviously been exterminated between these two regions by glacial action. *Dodecatheon amethystinum* is confined to the Driftless Area, except for isolated stations in parts of Missouri and Pennsylvania which escaped the glaciers. In *Hypericum Kalmianum* is an example of a plant which survived glaciation in the Driftless Area, then followed a line of glacial lakes northeastward through the Fox River valley to Lake Michigan, and migrated around the Great Lakes shores.

Objectives of chlorophyll research: C. F. KETTERING.

The absorption spectra of solutions of pure chlorophyll and of chloroplasts in living cells: V. M. ALBERS and H. V. KNORR. This investigation was undertaken to determine whether the absorption spectra of chlorophylls separated by the Willstätter methanol procedure were identical with the spectra of the chlorophylls separated by selective adsorption on sugar. All the chlorophyll was taken from a single original sample and showed a positive Molisch reaction, satisfied the cleavage and basicity tests and had a magnesium content of 2.7 per cent. Absorption spectra of the original chlorophyll *a* and *b* mixture and the two mixtures, made by mixing the two components separated by the above procedures in the proportion of three parts of *a* to one part of *b*, were determined by the method previously described.[1] These spectra indicate that, while the positions of the absorption bands in the visible region fall in very nearly the same positions in all three cases, the magnitudes of the absorption coefficients are quite different. The chlorophyll which had been treated by the method of selective adsorption on sugar showed a much greater difference from the original than that treated by the Willstätter methanol procedure. These results indicate quite definitely that the chlorophylls are changed in some way during the process of separation and that the changes produced vary with the method of separation. They also indicate that the use of the known chemical tests and the positions of the visible absorption bands are not sufficient criteria for comparison of two samples of chlorophyll. In order to eliminate the complicated scattering encountered in the living leaf, the absorption spectra of single chloroplasts were photographed, using a Hilger E,

[1] V. M. Albers and H. V. Knorr, *Jour. Chem. Phys.*, 4: 422–425, 1936.

spectrograph. The chloroplasts used were those in cells of Protococcus, Spyrogyra and Zygnema. They were mounted on the stage of the microscope and critically illuminated by means of a ribbon filament lamp. The image of the chloroplast was projected on the slit of the spectrograph, using a 4 mm objective with no ocular on the microscope. The plates were calibrated and absorption curves determined for the region from 704 mμ to 665 mμ. The region of absorption is found to be the same as that reported for the entire leaf. However, instead of a single band, four maxima, located at 668 mμ, 673 mμ, 678 mμ and 683 mμ, were observed. The relative intensities of these maxima are different in different chloroplasts, even in the same species.

Recent advances in the chemistry of chlorophyll: PAUL ROTHEMUND (introduced by C. F. Kettering). During the past few years the chemical research in the field of chlorophyll has led to a very intimate knowledge of the chlorophyll structure. It was demonstrated by Fischer that the isocyclic ring system attached to the hydrogenated porphin ring is responsible for a number of typical reactions of the pigment. One methylene group in chlorophyll and in its derivatives was found to be extremely reactive, as long as the magnesium atom was complexly linked to the molecule. Stoll observed the optical activity of chlorophyll solutions in monochromatic polarized light. It was possible for Fischer to prove that the "phorbin" system in chlorophyll contains two hydrogen atoms more than the porphin system. The same author identified a vinyl group in the molecule of chlorophyll *a* and *b*, and he also performed the partial syntheses of the following chlorophyll derivatives: chlorophyllide *a*, methyl chlorophyllide *a*, ethyl chlorophyllide *a* and pheophytin *a*. Our own synthetic work to obtain "porphin", the fundamental ring system of chlorophyll and of hemin, was successful: porphin and a large number of its derivatives and homologues were prepared synthetically by condensing pyrrole with suitable aldehydes. An interesting case of isomerism of porphyrins was found in connection with this synthesis. The syntheses of hydrogenated porphin and of the hydrogenated porphin ring in form of "phorbin" have not been accomplished so far. Our studies on the precursor of chlorophyll in plants led to the isolation of a green pigment, which is closely related to chlorophyll in elementary composition and in spectroscopic properties. The formula (Fig. 1) given herewith is the best expression of our present knowledge of the structure of chlorophyll *a;* in chlorophyll *b* the $-CH_3$ group attached to ring II is replaced by the formyl group $-C\overset{=O}{-H}$.

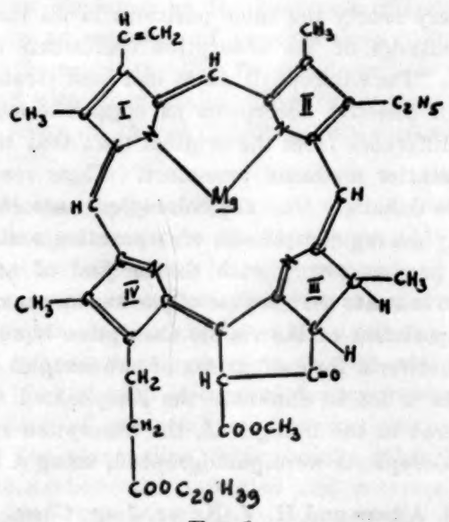

FIG. 1

The ratios of chlorophyll a and b and the mechanism of photosynthesis: ONDESS L. INMAN (introduced by C. F. Kettering). Sorby in 1872 investigated the proportions of chlorophyll *a* (blue chlorophyll) to chlorophyll *b* (yellow chlorophyll). He reported 100 parts of *a* to 0 of *b* in the olive and red algae. Leaves grown nearly in the dark showed a ratio of 100 parts of *a* to 5 or 6 parts of *b*. Healthy green leaves gave 100 parts of *a* to 13 to 17 parts of *b*. Willstatter studied many green plants and found on the average about three parts of chlorophyll *a* to one part of chlorophyll *b*. The brown algae ratio was found to be 19 parts of *a* to one part of *b*. It has been found that when the etiolated leaf of *Zea Mays* is irradiated for two and one half hours and the first evolution of oxygen detected by use of luminous bacteria, the ratio of chlorophyll *a* to chlorophyll *b* is 21.7 parts of *a* to one part of *b*. When the time of irradiation was four hours the ratio was 17.4 parts of *a* to one part of *b*. This indicates that the normal ratio of three parts of *a* to one part of *b* is not essential for photosynthesis, if one assumes that the process of photosynthesis is under way when the evolution of oxygen can be detected. Furthermore, it is reasonable to conclude that any theory of photosynthesis which supposes an equilibrium reaction between chlorophyll *a* and *b* should not require a constant value for the components *a* and *b*. If chlorophyll combines chemically with carbon dioxide, as has been postulated, such data would tend to point toward an assured combination with chlorophyll *a*. If, however, chlorophyll *b* does play the same part as *a*, then it seems most logical to assume that the part of the chlorophyll molecule which combines with carbon dioxide is a portion common to both chlorophyll *a* and chlorophyll *b*, such as, for example, magnesium or the additional five ring component or the phytyl group or some additional part of the natural occurring molecule which is not found in the purified product.

Spectroscopic analysis of hemochromogens: the ferriheme hydroxide-cyanide equilibrium: T. R. HOGNESS, F. P. ZSCHEILE, JR., A. E. SIDWELL, JR., and E. S. G. BARRON (introduced by W. D. Harkins). A precise spectrophotometric method makes possible the analysis of mixtures of hemoglobin derivatives, and consequently the study of equilibria involving these compounds. One of the equilibria studied is that between ferriheme hydroxide and cyanide ion. This study shows definitely that the ferriheme hydroxide is an associated compound and reacts to form ferriheme cyanide, according to the equation,

$$Hm_2(OH)_2 + 4\,CN^- = 2\,Hm(CN)_2^- + 2\,OH^-.$$

This is the first experimental evidence for the association of the ferriheme radical. On the basis of the accepted structure of ferrihemochromogens, there is no apparent explanation for the linkage which accounts for this association.

X-ray studies of the structures of biological materials: GEORGE L. CLARK (introduced by W. A. Noyes). Briefly outlined are the improvements in x-ray diffraction technique which have permitted studies of substances produced in living processes. Primary among these improvements is the resolution of interferences corresponding to very large periodicities—for example, 440 A. U. in collagen. Latest results are summarized on cellulose, chitin, rubber, keratin (human hair, feathers, pig bristle), living nerve, tendon collagen, intestinal wall collagen, muscle, albumin, hemoglobins, cereal proteins, etc. As an example of the usefulness of the diffraction pattern in biological research is cited the 48 A. U. equatorial spacing in intestinal wall collagen which led to the isolation, purification and analysis of a wax-like substance whose molecules are oriented radially on the fibrils and serve both to "lubricate" the fascial tissue and to protect the protein from enzyme digestion.

Slow ionic oxidation-reduction reactions: their mechanism and catalysis: PHILIP A. SHAFFER. Although many ionic reactions are immeasurably rapid there are numerous cases where thermodynamically possible reactions between demonstrably "active" ions are surprisingly slow or even fail to take place without catalysts. In some cases ionic reactions proceed much faster when *separated* in the form of a battery (electro-chemical cell) than when in a single solution. Survey of a number of cases among oxidation-reduction reactions indicates that a simple but hitherto unconsidered quality of the individual ions is frequently an important rate-controlling factor, and appears to explain this strange behavior: namely, the equality or inequality of permissible valence-change. Rapid reactions probably result always from *bi*molecular collisions or a sequence of these. In oxidation-reduction reactions the transfer of electrons from reductant to oxidant requires (in a bimolecular process) "common consent" as to the number to be lost and accepted. Disagreement, because of inability to assume the resulting "impossible" valence state, makes the reaction depend upon third or higher order collisions which are much less frequent events. Like or unlike charge of ions is another factor of less importance. A survey of the periodic table with respect to reactions of elements known in plural valence states indicates many instances which appear to support this simple hypothesis. Greater consideration of characteristic properties of the individual ions, in addition to the present concept of energy levels and "activation energy," is advocated as necessary for progress in the still obscure subjects of chemical kinetics and catalysis.

The rôle of the macrophage in the mechanism of recovery from experimental lobar pneumonia in the dog: O. H. ROBERTSON (introduced by F. R. Lillie). Recent observations on the histological pathology of experimental pneumococcus lobar pneumonia in the dog have shown that the onset of recovery is accompanied by a change in the character of the intra-alveolar cellular exudate from a predominantly polymorphonuclear to a large mononuclear type of cell. These latter cells are for the most part typical macrophages and appear to be derived to a considerable extent from the fixed tissue cells of the lung parenchyma. Associated with this cellular change is a diminution or complete disappearance of pneumococci, due apparently to their phagocytosis by the macrophages. That the mobilization of the macrophages in the lung plays a significant rôle in the termination of the disease is attested by the following experimental findings: (1) The disappearance of pneumococci from lesions in which resolution is occurring during the active phase of the disease when spread of the inflammatory process to other parts of the lung is taking place. (2) The demonstration that the resolving lung constitutes a lethal environment for actively growing, freshly introduced virulent pneumococci. The lung loses this property to a considerable extent upon its return to a normal histological appearance. (3) Studies of macrophage exudates both *in vivo* and *in vitro* have shown that these cells are capable of destroying large numbers of ingested pneumococci within a few hours and that they carry on this process much more effectively than do the polymorphonuclear leucocytes in the presence of relatively weak opsonic fluids.

Some chemical properties of an essential growth factor for pathogenic bacteria: FELIX SAUNDERS and STEWART A. KOSER (introduced by H. G. Wells). Many bacteria, especially the pathogens, develop quite readily in a meat infusion culture but are unable to grow in a simple synthetic medium. If a meat infusion is shaken with charcoal the growth-promoting substance(s) is absorbed and the infusion will no longer support the growth of pathogens. If the charcoal is extracted with boiling alcohol the growth-promoting factor can be eluted and if it is added to a synthetic medium containing inorganic salts, dextrose and amino acids the pathogens will grow. Control tests show that growth is due to a true growth factor and not to the addition of some nutrient to the medium. The growth factor is widely distributed, since it can be isolated from many different kinds of tissue of both plant and animal origin. It is active biologically in extremely small amounts. Only a few gamma are necessary to activate a liter of synthetic medium. Chemical studies show that the growth factor is a substance of low molecular weight. Its most striking property is a remarkable stability. It is heat-stable, resistant to strong oxidants, acids and alkalis. Growth-promoting activity is not destroyed by bromine, ammoniacal silver, acetic anhydride or nitrous acid. The substance is soluble in acetone, methanol, ethanol and phenol but is insoluble in ether, benzene, chloroform and higher alcohols. It does not contain sulfur and is probably inorganic since it is destroyed by ashing.

Experimental meningococcal infection: C. PHILLIP MILLER (introduced by Ludvig Hektoen). Experimental meningococcal infection has been produced quite regularly in the mouse by intraperitoneal inoculation of meningococci suspended in mucin. Of virulent strains approxi-

mately 10 organisms suffice to initiate a lethal infection with invasion of the blood stream. The action of mucin is not clearly understood, but seems to involve interference with the defense mechanism of the host rather than enhancement of the virulence of the micro-organisms themselves. Mice can be protected against infection by preliminary injection of immune serum, which is type specific if monovalent, and they can be spared a fatal outcome if serum is administered in sufficient quantity, even though the infection is quite far advanced.

A study of genital mycosis: H. CLOSE HESSELTINE (introduced by A. J. Carlson). Certain significances of the yeast-like fungi in the female reproductive tract have been demonstrated only recently. The incidence appears to be related partly to the hygienic state. The discussion will give incidences in the pregnant, gynecologic and diabetic patient, include identification problems of the monilia and cryptococci, suggest the influence of available glucose, offer additional evidence that the sporadic oral thrush of the newly born is contracted from the mother, designate avenues now open for therapeutic improvements, and indicate some difficulties in accomplishing cures.

Blood volume changes in eclampsia: WILLIAM J. DIECKMANN (introduced by F. R. Lillie). Changes in blood and plasma volume in eclampsia have been determined by making serial examinations of hemoglobin, hematocrit and serum protein concentration. Determinations of plasma and blood volume have been made with the Congo red method and indicate that in eclampsia there is a very marked concentration of the blood.

A study of the action of some oxytocics, especially ergonovine, on the postpartum uterus: FRED L. ADAIR, M. EDWARD DAVIS and SARAH A. PEARL (introduced by A. J. Carlson). The chemistry, pharmacology and clinical application of a new alkaloid isolated from ergot, ergonovine, which contains most of the desirable oxytocic activity in ergot, was discussed. The various experimental procedures resulting in the isolation of this alkaloid were briefly sketched. A comparison was made of this new oxytocic drug with other oxytocic drugs. A method of studying contractions of the post partum uterus was described and some of the results were presented.

Some relationships between structure and function of organic arsenicals in experimental chemotherapy: ARTHUR L. TATUM (introduced by A. J. Carlson). A large number of organic arsenicals were used to treat laboratory animals, mostly rats, infected with various species of trypanosomes. A result of such a survey revealed the possibility of grouping the drugs into categories according to their effectiveness. The members of one group of arsenicals were effective in curing infections caused by any of several species which are distinctly pathogenic to the host (*T. equiperdum, brucei, rhodesiense*). The members of the other group of arsenicals were effective in curing rats infected with a relatively non-pathogenic species (*T. lewisi*). Those drugs effective on *T. lewisi* were mostly quite ineffective on the pathogenic species, and conversely those drugs effective on the pathogens are ineffective on the non-pathogen. Similar relationships hold true in *in vitro* susceptibility of the organisms toward the drugs. The arsenicals effective on *T. lewisi* possess a carboxyl group, *i.e.*, an acidic group, whereas those drugs effective on the pathogens have alcoholic or amine groups, *i.e.*, basic groups. The differences in ease of cure of the animals infected by different members of the pathogenic series appear to reside in differences in parasite-host relationships. It can scarcely be due to drug-to-parasite relationship, since *in vitro* drug-to-parasite relationship is relatively the same, whereas actual curability of the infected host differs very markedly with different pathogenic species.

The acid-base and energy metabolism of the stomach and pancreas: MARTIN E. HANKE. The metabolism of the stomach and pancreas was studied in dogs by comparative analysis of the venous blood from these organs and arterial blood simultaneously taken. The experimental determinations on the blood were pH, CO_2, O_2 content, O_2 capacity and per cent. water. Comparison of the available base differences in the blood with the acid and alkali in the gastric and pancreatic secretions has shown that in the case of the stomach the two values are equal within experimental error, while in two experiments in the pancreas the latter is about twice the former, and the relation is more variable. The rate of blood flow through the stomach and pancreas was calculated from the difference in the water content of the arterial and venous bloods and the volume rates of secretion of the two juices, on the assumption that the secretion of water in the juices is quantitatively reflected in a decrease in the water content of the corresponding venous blood. Thus a 20-kg dog, with a mucosa weight of 80 gm, a water difference of arterial and gastric venous blood of 0.5 per cent., and a secretion rate of 1.1 cc of gastric juice per minute, has a blood-volume flow of about 60 cc per minute through the stomach. Calculation of the energy metabolism of the actively secreting stomach from the difference in the O_2 content of arterial and gastric venous blood (about 2.4 millimols O_2 per liver of blood) shows a production of 0.14 gm-calorie per minute per gram of mucosa, or 13.5 gram-calories per cc of gastric juice. Calculation of the free energy of formation of the constituents of gastric juice from blood or lymph from the equation $\Delta F = NRT \ln \frac{C \text{ gastric juice}}{C \text{ blood}}$ shows for hydrogen-ion -1.22 gram-calories, for other ions, Na, K, NH_4 and Cl and water, about $+0.10$ gram-calorie, a net total of -1.1 gram-calories per cc of gastric juice. Assuming that there are no other significant sources of energy in gastric-tissue metabolism besides the conventional oxidation of carbohydrates, fats and proteins, it follows that the minimum osmotic work involved in gastric-juice formation is about 9 per cent. of total energy metabolism of the stomach. Similar conclusions have been reached by Teorell (*Skand. Arch. Physiol.*, 66: 279, 1933), using other methods and another species. Similar calculations of data from experiments on the pancreas show a total metabolism of 8.6 g-cal. (an increase over resting metabolism of 5.0 g-cal) for 1 cc of pancreatic juice. The sum of the free energies of formation of the constituents of pancreatic

juice from blood is about 0.5 cal per cc of pancreatic juice. The ratio of these two values is about 6 per cent. (10 per cent. for the increase over the resting metabolism). These "efficiencies" $\frac{\text{free energy}}{\text{total tissue energy}}$ per unit volume of secretion, are much greater in the case of the stomach and pancreas than they are for the kidney, where the quotient is about 1 per cent. (Borsook and Winegarden, *Proc. Nat. Acad. Sci.*, 17: 13, 1931).

Active and blocked embryonic cells—some phases of their physiology: J. H. BODINE (introduced by Carl E. Seashore). Quantitative physiological studies have been made on actively developing and blocked embryonic cells in an attempt to learn further concerning the "block mechanism" normally occurring in certain cells. Rates of oxygen consumption, the effects of carbon monoxide, oxygen lack, cyanide, methylene blue, etc., on the resting and active stages of the embryonic cell have been investigated and an analysis made of the respiratory mechanisms involved.

The formation and fermentation of hexosemonophosphate in muscle: CARL CORI and G. T. CORI (introduced by Joseph Erlanger).

The scientific analysis of piano performance: C. E. SEASHORE. A camera has been devised to measure in adequate detail and graph photographically the characteristics of the player's performance on the piano. The pianist has at his disposal only two variables; namely, time and intensity. Pitch is determined by the instrument; so also is the timbre, except in so far as it can be modified by overholding with key or pedal. The graph of the performance is made on a standard 4" film in the time that it takes to play the selection. Time is measured in .01 sec., and intensity in decibels is measured in terms of the rate of impact of the hammer. This photographic chart is condensed into a musical pattern score.

Stroboscopic studies of the human vocal cords: DR. JOSEPH TIFFIN (introduced by Carl E. Seashore). Stroboscopic moving pictures of the vocal cords in action will be shown. These slow-motion pictures indicate the form of vibration of the vocal cords. Analysis of the cordal movement tends to substantiate the Helmholtz theory of vowel production.

Histological studies of the respiratory portion of mammalian lungs: CLAYTON G. LOOSLI (introduced by C. J. Herrick). A detailed study by various histological methods of the lungs of the monkey, dog, cat, rabbit, rat, guinea-pig, opossum and mouse, killed at various stages of postnatal development, has been made. In these animals a continuous epithelial membrane lining the respiratory portion of the lungs is not found. The alveolar wall is made up essentially of a central stroma of reticular and elastic fibers and connective tissue cells. The meshes of the fibers support a network of blood capillaries which form loops which bulge into the adjacent alveolar spaces. An amorphous ground substance or membrane covers the fibers, cells and capillaries. Isolated nucleated cells are scattered over the alveolar walls. Some of the intercapillary spaces in the alveolar walls possess openings or pores which connect adjacent alveoli.

Transmission of successive impulses across synapses: HELEN TREDWAY GRAHAM and RAFAEL LORENTE DE NÓ (introduced by Joseph Erlanger). Normal functioning of the nervous system involves transmission of impulses along a succession of neurones at frequencies ranging from about 5 to 100 per second (intervals of 10 to 200 milliseconds between impulses). Passage of an impulse along the peripherally-placed axons of certain of these neurones—the peripheral nerve fibers—produces long-lasting changes of excitability to electrical stimulation; under certain conditions the fiber after 5 to 10 milliseconds may be more excitable than normally, while after 20 to 100 milliseconds it may be less excitable. It will be observed that these intervals come within the range frequently observed in normal functioning of the nervous system, and it is therefore conceivable that similar changes of excitability, if they occurred under physiological conditions, might play a rôle in the explanation of certain aspects of central nervous activity (facilitation, inhibition, etc). In the physiologically functioning nervous system, however, each neurone is stimulated not by electrical shocks applied to its axon but by the arrival of impulses at the end knobs of the axons of neurones preceding it in the path of transmission. Such stimulation across neurone junctions or synapses may be called synaptic stimulation. The recovery of excitability to this normal synaptic stimulation has been tested by stimulating electrically the neurones ending in synapses with the motoneurones of the trochlear nerve or internal rectus muscle (rabbit eye) from which the impulses were recorded. It has been found that there is no period of increased excitability to such synaptic stimulation, but instead a protracted period of depressed excitability. This depression, which lasts 30 to 50 milliseconds after one impulse, becomes longer and more intense after a succession of impulses (2 to 9 impulses at frequencies of 45 to 200 per second have been found to increase the depression significantly). It appears therefore that certain forms of inhibition in the central nervous system may be explained by changes of excitability to synaptic stimulation and, in particular, that the gradual decrease in excitability with the passage of a train of impulses may account for such phenomena as the dying out of rhythmic activity.

Potentials in the frog's nervous system: R. W. GERARD (introduced by A. J. Carlson).

Some effects of histologic procedure on cells: G. W. BARTELMEZ (introduced by C. J. Herrick).

The secretion of hydrochloric acid in the stomach as revealed by the freezing-drying method: N. D. HOERR (introduced by C. J. Herrick).

Lipocaic, a new pancreas hormone: LESTER R. DRAGSTEDT, JOHN VAN PROHASKA and PAUL B. DONOVAN (introduced by A. J. Carlson). The observations of Fisher (1924) and of Allen, Bowie, Macleod and Robinson (1924) and others that completely depancreatized dogs adequately treated with insulin usually die within two months with

extensive fatty infiltration of the liver was confirmed. The absence of pancreatic juices from the intestine is apparently not the cause of this liver damage, since it was absent in animals with complete pancreatic fistulae and in dogs whose pancreatic ducts had been ligated and the pancrease extensively degenerated. The administration of fresh activated dog pancreatic juice in amounts of from 1,000 to 1,100 cc per day did not prolong the lives of depancreatized dogs nor prevent the development of the typical liver changes. The oral administration of as little as 25 gm of fresh beef pancreas per day was found sufficient to either prevent or to cure the fatty infiltration and to permit survival. Choline is apparently not the substance in pancreas which accounts for this effect, since as much as 700 gm of choline per day were found to be entirely ineffective. An extract was prepared from fresh beef pancreas and found to be effective in curing and preventing the development of fatty infiltration in the liver of depancreatized dogs adequately treated with insulin. This extract is believed to contain a new hormone, for which we have suggested the name "Lipocaic," which plays a rôle in the metabolism of fat. Some properties of this new hormone are described.

The mechanism of the lytic action of bacteriophage: J. BRONFENBRENNER (introduced by Joseph Erlanger).

The antirachitic effect of tartrate and citrate: BENGT HAMILTON and M. DEWAR (introduced by H. G. Wells). On the basis of certain theoretical considerations it was thought possible that the oral administration of tartrate or citrate would prevent the development of rickets in rats on a rachitogenic diet. This prediction proved to be true, the salts proving to have a preventive effect as marked as that of cod liver oil. It was also shown that fully developed rickets could be effectively healed by the addition of these salts to the rachitic diet, although the healing effect was not, perhaps, as marked as that of vitamin D. The cause of this antirachitic action of tartrate and citrate is not quite clear.

Termite nests—a study of the phylogeny of behavior: A. E. EMERSON (introduced by C. M. Child). Termite nests may be used as examples of behavior evolution because they are morphological indications of behavior patterns, they express the behavior of a population, the patterns are hereditary, there is a natural control over any Lamarckian influence, evolutionary sequences are available, adaptive modifications may be demonstrated, and coordination mechanisms may be partially analyzed. Wood-eating roaches, similar to the hypothetical ancestor of the termites, excavate galleries in wood but make no constructions. The Kalotermitidae excavate wood and construct partitions indicating responses to humidity and mechanical or chemical factors. The Mastotermitidae exhibit a quantitative advance in nest construction compared to the Kalotermitidae. The Hodotermitidae show a further advance with subterranean nests, elaborate carton construction and food storage. The Rhinotermitidae have separately evolved subterranean adjustment and in some species show building activities in response to social factors as well as physical factors. Excavated subterranean nests of the Termitidae exhibit the influence of mechanical and spatial factors. Materials may be dirt, wood or excrement, cemented by saliva or excretions. Structures consist of covered tunnels, roads, rain-shedding projections and ridges, nests of characteristic size and differentiation, ventilation pores in the walls, stored food and fungus gardens. Sterile workers and nymphs of sterile soldiers and workers construct the nests in the Rhinotermitidae and Termitidae. The ecological functions of the nest are the control of temperature, the control of humidity, the protection from predators and harmful fungi—all enabling the termites to live in otherwise uninhabitable niches. The nesting site may be selected partly or wholly by the colonizing pair, but often is selected by the workers followed by a colony migration. Height of the nest from the ground may be fairly characteristic of the species. Different species within a genus may show great divergence in nesting behavior. Species of the genus *Amitermes* have subterranean nests, mound nests, arboreal nests, nests oriented with reference to the sun and rain-shedding constructions. Convergent evolution of rain-shedding constructions has occurred in the Amitermitinae, Termitinae and Nasutitermitinae. "Intelligence" of termites reported in the literature is usually strongly anthropomorphic. Behavior evolution should be correlated with morphological evidences of evolution. Degenerative evolution of behavior patterns may be explained by modern genetic theory.

An evolutionary analysis of insular and continental species: ALFRED C. KINSEY (introduced by C. M. Child). Insular and continental forms so differ in their constitution and behavior that evolutionary theories adequate to the one type of species are not all applicable to the other. In an attempt to evaluate the evolutionary data from the laboratory genetics, the gall wasp family Cynipidae is being used as the basis of an intensive study of species as they actually occur in nature. Among the more than 300 species so far studied, most of the forms which match the current concepts of continental species are located in the eastern half of the United States. There the uniform topography offers few geographic factors to isolate species, and even distance may fail as a factor because of the recent interchanges of faunas and floras consequent on the Pleistocene glaciations. These species all have large ranges, and they show considerable intra-specific variation, local subdivisions of each population, and extensive intergradation from one species to the next. In the western half of the United States, and throughout Mexico and Guatemala, the highly varied topography and multiplicity of the oak hosts of these insects provide isolating factors as effective as the waters surrounding oceanic islands. The essentially insular species occurring there have relatively small ranges, often show a minimum of individual variation (although in some cases the variation is great), rarely develop local variations within the populations, and almost never develop intergrades between species. The Darwinian concept of accumulative variation seems inapplicable, while the laboratory data of mutation seem sufficient explanation of the origin of most of these species. There seems to have been some an early isolation of the new types on the peripheries

the ranges of the parental species that gene frequencies were soon reduced to equilibrium. While the interspecific gradation between continental species is usually taken to substantiate Darwinian concepts of the multiplication of species through gradual transitions, the intermediate groups seem more exactly analyzed as hybrids between what were originally isolated stocks. Thus the evolutionary pattern laid down by insular species may be taken as basic to the interpretation of continental species. In continental species, however, the chance that interspecific hybridization may give rise to a new species is much greater than among insular species.

Meteorological environment and organic differentiation: W. F. PETERSEN (introduced by F. R. Lillie). In the material presented, confirmation of the Hippocratic suggestion of the rôle of the meteorological environment during the early development of the embryo (paratypic differentiation) is sought. It is assumed that with periods of greater meteorological turbulence the more profound autonomic disturbances of the maternal organism (uterine vascularization and tonus) will disturb the uniformity of environmental conditions for the rapidly developing embryo, with the possibility of optimal stimulation on the one hand as well as injury on the other. An examination of the seasonal conception distribution, of still births, of birth rhythm and premature delivery is first presented. There follows evidence for mental differentiation, including unusual intelligence, feeble-mindedness, the criminal type, the criminal insane and the insane. A study is made of adult habitus with relation to the period of conception, as well as a study of the conception periods of groups who have died from various diseases, including tuberculosis, endocrine disturbances, leukemia, diabetes, etc. A discussion of the possible mechanisms involved and of the significance for racial differentiation.

The laws governing the distribution of bone marrow in the extremities in mammals: CHARLES HUGGINS (introduced by F. R. Lillie). In newborn mammals all bone marrow is red. Soon a peripheral regression of red marrow takes place, and the adult state consists of a central accumulation of red marrow with a peripheral yellow marrow. A thermal decrement has been found in the peripheral bone marrow as compared with the central areas. Elevation of temperature of the outlying regions causes a retention of red marrow or a regression of yellow marrow with replacement by blood-forming tissue.

Establishment of diurnal temperature curve in the child: N. KLEITMAN and S. TITELBAUM (introduced by A. J. Carlson).

A study of certain fatigue symptoms in mental work: A. G. BILLS (introduced by C. J. Herrick). The proposed report brings together the main results of a program of research designed to get at the basic principles of mental fatigue, by analyzing the behavior changes resulting from continuous mental work. The discovery of a hitherto unrecognized fatigue symptom, the "block" or enforced pause, occurring more or less periodically at frequent intervals during work, led to studies of the following special problems: (1) The progressive increase in length and frequency of blocks with prolonged work; (2) the decrease resulting from practice in the task; (3) the effect of kind of task and rate of work; (4) the relation of blocks to error causation; (5) a comparison of blocking in manual and in vocal performances; (6) the exaggeration of the phenomenon in the manual (as well as vocal) performance of stutterers; (7) the relation of the block rhythm to various rhythmic physiological activities, such as breathing; and (8) an investigation of the relation of blocking to nervous metabolism, by noting the effect of systematically varying the oxygen supply of persons engaged in mental work, and the effect of breathing pure oxygen on the performance of persons already fatigued from an hour of mental work. The results indicate that the block is the most sensitive objective fatigue symptom; that it probably serves a function similar to refractory phase, in giving frequent short rests to the reacting mechanisms which prevent excessive exhaustion; and that it is independent of any specific organic rhythm. It occurs in manual responses as well as vocal; is exaggerated in stutterers, and in hesitant speakers; and is a major factor in error causation. It is exaggerated in proportion to the homogeneity and complexity of the task. It is exaggerated under conditions of anoxemia, in inverse proportion to the percentages of oxygen used and the duration of the work period. The excessive blocking present in fatigued workers is apparently reduced by breathing pure oxygen. These last findings suggest a close relation of blocking to the oxygen metabolism of either the nervous or sensory motor mechanisms.

Contrasts in the genetic effects of ultra-violet radiation and x-rays: L. J. STADLER and G. F. SPRAGUE (introduced by Sewall Wright). Ultra-violet radiation applied to mature pollen of maize induces mutation and deficiency, but unlike x-ray treatment it has little or no effect on the frequency of translocation. The endosperm deficiencies induced by UV include a larger proportion of fractionals, and the relative frequency of loss of specific marker genes differs distinctly from that found under x-ray treatment.[1] Since the frequency of deficiency was lower under the UV doses used than under the x-ray doses commonly applied, it is possible that the difference in effect on translocation is incidental to dosage. If translocations result from chromosome breakage followed by reattachment of broken ends in new combinations, translocation can occur only in cells with two or more breaks. The rarity of translocation following UV treatment may then be due to the smaller number of breaks produced by the UV dose applied. A further trial was made, comparing a maximal dose of UV with a rather low dose of x-rays. These doses were approximately equal in total frequency of induced deficiencies for the endosperm genes *A* and *Pr*, the UV treatment producing about one third as many deficiencies affecting the entire endosperm and two and one half times as many fractionals as the x-ray treatment. The frequency of translocation was determined for each treatment by direct cytological examination of about 100 unselected

[1] *Proc. Nat. Acad. Sciences*, in press.

plants of the F_1 progeny. Only one translocation was found in the UV progeny, while 44 per cent. of the plants of the x-ray progeny showed translocations, several of them two or more independent translocations. The frequencies of plants with segregating defective pollen were 14 per cent. and 77 per cent., respectively.

The reality of neurofibrils in the living ganglion cell and nerve fiber: PAUL WEISS (introduced by C. J. Herrick). Photographs were presented demonstrating the existence of neurofibrils as discrete filaments, both in the cell body and the axone of living ganglionic cells of chick embryos grown in tissue culture but otherwise untreated. The experiments (done with the assistance of Mr. H. Wang) consisted of explanting embryonic spinal ganglia into blood plasma under provisions permitting direct microscopic observation. The gradual appearance in the healthily growing and differentiating cells of neurofibrils was observed in the course of prolonged cultivation up to two weeks. These observations seem to end the old argument of the reality versus artifact nature of neurofibrils in the living undisturbed cell, specifically in regard to warm-blooded vertebrates.

The physiological basis of heterosis: R. A. BRINK (introduced by Sewall Wright). Cross-fertilization in *Medicago sativa,* using an unrelated strain as the pollen parent, increases the proportion of functional seeds formed several fold, as compared with self-fertilization under the same conditions. The disparity results from a much lower incidence of abortion during development in the case of the hybrid embryos. The superior ability of the latter to continue growth to maturity may be considered a manifestation of heterosis. It is a well-recognized fact that growth in certain regions of the plant tends to suppress it in many other potential centers of similar activity. Immature embryos are subject to the conditions imposed by this growth-regulating mechanism and continue development or abort according to the reciprocal relation established between them and their environment in the host plant. The increased capacity of hybrid as compared with inbred embryos in Medicago to complete development may be accounted for on the assumption that the primary effect of outcrossing on the physiology of the resulting zygote is to shift the balance in the growth-regulating mechanism in favor of the forward processes and against the retarding influences. The nature of the growth-regulating mechanism is obscure, but some facts concerning it are available which enable one to visualize how such a shift might be effected. There is much evidence suggesting that heterosis in general may rest upon a physiological basis of this sort.

The oxidation-reduction potentials of hemin and some hemochromogens: E. S. G. BARRON (introduced by H. G. Wells). The importance of hemin and of the nitrogenous derivatives of hemin, the hemochromogens, has increased considerably during the last years. Because they are electromotively active oxidation-reduction systems, they act as catalysts of most of the biological oxidations. Since the catalytic power is conditioned by the relation between the free energy of the catalyst and the free energy of the oxidizable substance, a knowledge of these free energies is essential for the understanding of the mechanism of biological oxidations. The free energy (as determined by measuring the oxidation-reduction potential) of hemin and of a number of hemochromogens (cyanide, nicotine, pyridine, α-picoline, pilocarpine, histidine) has been studied. It has been found that the oxidation reduction potential of hemin becomes more positive on its conversion to hemochromogen, the potential varying with the nature of the nitrogenous compound attached to hemin. Thus at pH 9.50, the E'_0 of hemin is −0.235 volt; that of cyanide-hemochromogen is −0.182 volt; of pilocarpine-hemochromogen, −0.156 volt; of histidine-hemochromogen, −0.138 volt; of α-picoline-hemochromogen, −0.022 volt; of pyridine-hemochromogen, +0.017 volt; of nicotine-hemochromogen, +0.053 volt. The ratio $\frac{\Delta E'_0}{\Delta pH}$ of hemin changes with a slope of −0.06 volt per pH unit from pH 7 to 9.2, and with a slope of 0.09 from pH 9.2 to 12. The E'_0 of cyanide-hemochromogen remains constant. The E'_0 of the other hemochromogens changes with a slope of about 0.06 volt per pH unit. Pyridine and nicotine-hemochromogens, at pH 11, give titration curves similar to that of systems with 2-electron transfer, due possibly to polymerization. Hemin and the other hemochromogens pass from the oxidized to the reduced state with a transfer of one electron. The fact that the potential of hemin can be changed to varied levels of energy by the addition of nitrogenous compounds explains why catalysts containing hemin as the active nucleus, to which are attached a variety of nitrogenous compounds, oxidize selectively a considerable number of oxidizable substances of different free energies.

Variation in Ustilago zeae: E. C. STAKMAN. *Ustilago zeae,* the fungus that causes corn smut, comprises an indefinite number of strains or lines. This fungus is especially suitable for studies of heritable variations, because single unicellular, unisexual individuals can be isolated and propagated vegetatively on nutrient media in the laboratory, thus giving rise to unisexual lines. Barring mutation, all individuals in any one of these lines are the alike in their heritable properties, as has been shown by extensive studies. But innumerable new lines can be produced by hybridization between lines and by mutation within lines. Even from the progeny of two unicellular individuals of opposite sex that were crossed about three years ago by the writer and his associates, hundreds of lines have arisen as the result of segregation and mutation in laboratory and greenhouse cultures. These lines differ from each other in one or more of the following characters: type of growth; color, size and topography of colonies on artificial media; sex and parasitism; and tendency to mutate. Several hundred mutant lines have been isolated and studied; some are conspicuously different from each other, and others differ in almost imperceptible but distinctive characters. Factors for the new mutant characters are inherited when mutant lines are crossed with lines of opposite sex. The tendency to mutate is itself due to heritable factors and differs greatly in different lines. When crosses were made between mutable and con-

stant lines, some of the resulting segregates were very mutable, others moderately so, and still others were constant; but by crossing the most mutable lines with each other for several generations material has been obtained in which all segregates are extremely mutable.

Seed-cone development in Sequoia gigantea: J. T. BUCHHOLZ (introduced by William Trelease). For *Sequoia gigantea*, the information concerning seed-cone production has been very fragmentary. This information is essential as a first step in a study of the embryology of this species. The cones are evergreen and persistent for many years after the morphological development of the embryo is completed within the seed. Some measurements have been made on the diameters of the leaders, the seed-cone-bearing branches, vegetative branches and pollen-cone branches. New methods have been worked out by which the dates of origin, pollination and development of the cones may be determined even after many years so that most of the cones and their seeds may be dated with a fair degree of accuracy. Seed cones require three years in their formation. They are formed at the tips of branches during the summer of a given season, pass the first winter within a bud and are pollinated during April of the following spring. During the summer of the same season, the cones enlarge very greatly, becoming full grown, hard and woody in August. Fertilization takes place during the last week in August. The embryos begin to develop, but pass the winter in a very immature condition and require still another season for their growth, so that they are morphologically developed only by the end of the second year following pollination or at the end of the third year after the formation of the cone primordium at the tip of the stem. The embryo is very small during the first month after fertilization and undergoes cleavage polyembryony. The smallest stage of the embryo observed thus far, a 2-celled stage after cleavage of the zygote, was 20,000 cubic microns. Thus, in the big tree which may eventually reach a volume of 1,640 cubic meters (estimated for the General Grant tree), the organism enlarges 82×10^{15}-fold. The mature specimen of *Sequoia gigantea* is as much larger than its embryo as the earth is larger than a building similar in size to the dome of the Adler Planetarium.

Reaction gradients and pigmentation thresholds in the feather germ: RICHARD M. FRAPS (introduced by C. M. Child). Lillie and Juhn published in 1932 a detailed account of the order of localization, extension and reversion of patterns induced in breast and saddle feathers of the Brown Leghorn capon by injection of hormones (female hormone and thyroxin). On the basis of these and other data they concluded that the feather germ is subject to growth-rate distributions which determine orders of reaction to the hormones employed. The "high" end of this gradient in rates is at the ventral limit of pigmentation (apex of the individual barb), from which point rates decrease gradually to minimal values at the dorsal limit of the germ (base of the individual barb). An extension of similar experimental procedures to induction of pattern modifications in other tracts has produced orders of pigmentation which are completely or partially the reverse of those described by Lillie and Juhn (unpublished data of Mary Juhn). On the assumption that the forces tending to effect alternative pigmentation reactions are *differential functions* of the primary rate gradient, these orders of pigmentation are completely accounted for without change in direction of the ventro-dorsal (or apico-basal) gradient postulated by Lillie and Juhn. Alternative pigmentation thresholds become, on this view, functions of the relation between the assumed differential gradient functions. The hypothesis accounts satisfactorily for experimental results specifically in the Brown Leghorn, and may possibly be of value in interpretation of phenotypic pigmentation combinations found in the plumage of this breed.

Spectrographic analysis of pure samples of cytoplasm and nuclei from liver cells: GORDON H. SCOTT (introduced by Joseph Erlanger).

The conjugated form of male sex-hormone in human urine: DUREY H. PETERSON, T. F. GALLIGHER and F. C. KOCH (introduced by J. Stieglitz). Heretofore the yield of male-hormone activity as extracted from acidified urine without boiling and with boiling for two hours or longer was practically the same. We now find that when the acidified urine is boiled for fifteen minutes, the yield of male hormone is increased by approximately 70 per cent. over the no-boiling or the two or more hours boiling process. This is true for men's and women's urine. The results suggest that a conjugated form of male hormone is liberated by acid hydrolysis and that this is subsequently destroyed by boiling with acid.

Some effects of numbers present on the rate of first cleavage in Arbacia: W. C. ALLEE and GERTRUDE EVANS (introduced by C. M. Child). Other things being equal, under the conditions tested, *Arbacia* eggs cleave sooner if in moderately dense groups than if isolated or with few present in the same volume. Cleavage is delayed if too many eggs are piled upon each other. With temperature, evaporation and other pertinent variables controlled, these relations held when tested in volumes that varied from drops of 10 cu mm to vials with two cc of sea water. In the latter case, positive acceleration from crowding was obtained with as many as approximately 10,000 eggs present, when contrasted with accompanying lots of a few tens of eggs. Two techniques were employed: In one, the time to 50 per cent. cleavage was found for living eggs at the first and second cleavages. In approximately 90 paired experiments of different kinds, the mean time to first cleavage was 0.88 minutes faster in the denser populations and to second cleavage, this increased to 2.24 minutes. The respective statistical significances are: $P = 0.053$ and $P = 0.0016$ when $P = 0.05$ is equivalent to three times the probable error. The smaller the value of P, the greater the statistical significance. With the second technique, the eggs were allowed to develop to some selected critical stage and then were killed serially, with one dense and several sparse populations killed approximately simultaneously. A total of 47 paired experiments of different kinds showed that

near mid-cleavage the denser lots, on the average, were 14 per cent. ahead at first cleavage, 14–20 per cent. ahead at second cleavage and 10 per cent. ahead at third cleavage, as compared with accompanying sparse lots. The respective statistical probabilities are: $P = < 0.0001$, $P = 0.015$ to 0.0008 and $P = 0.0002$. We know that somewhat similar results can be produced by the presence of certain toxic substances, as in other and better analyzed cases of mass protection; great care was taken to avoid such contamination in this work. Analysis of the causal factors involved has given only negative results to date. These tests included increasing artificially the carbon dioxide content of sea water to various slight degrees, and the use of egg-conditioned sea water which had been prepared by several different methods. Hence while the effect itself is real, the underlying processes are still unknown.

Some derivatives of the neural folds in amphibian embryos: pigment cells, spinal ganglia and Rohon-Beard cells: GRAHAM P. DUSHANE (introduced by C. M. Child). Experiments involving bilateral excision and transplantation of the trunk neural folds indicate that the following diverse elements are derived from the folds: (1) pigment cells (xanthophores, guanophores and melanophores) of the dermis and the deeper structures (pericardium, mesenteries); (2) spinal ganglion cells; (3) Rohon-Beard or giant ganglion cells. Such embryos later show motor responses to tactile stimuli applied to head or tail, but no response to trunk stimulation. Rohon-Beard cells are absent from the insensitive region and present in the sensitive areas (head and tail). Despite the fact that the Rohon-Beard cells, which normally form the sensory tract in the spinal cord, are absent from the trunk, sensory impulses pass from the tail headward through this region. It is probable, as Coghill has suggested in a personal communication, that the Rohon-Beard cell axons extend from the tail to the anterior part of the spinal cord, thus forming the ascending tract. Coghill's preparations show axons of hitherto unsuspected length. One such process could be followed through six segments of the spinal cord. The fact that the Rohon-Beard cells and spinal ganglion cells have a common primordium lends some support to the idea that they are homologous. It is of further interest that there is no regeneration of pigment, Rohon-Beard and spinal ganglion cells following the removal of the neural folds.

Comparisons of the relative growth velocities of the various mineral constituents with body growth in the human fetus and the young rat throughout the nursing period: W. W. SWANSON and VIVIAN IOB (introduced by A. J. Carlson). Graphical presentations are used to show the relative velocities of growth in per cent. per lunar month for the various mineral constituents of the human fetus, and the relative velocity of growth of the same minerals during the nursing period of the infant and the suckling period of the young rat.

Studies of correlations between measured mental and physical differences in identical twins reared apart and rated differences in the environment: H. H. NEWMAN (introduced by F. R. Lillie). This represents one aspect of a study of hereditary and environmental factors responsible for twin differences and, by inference, for human beings in general. The work has been done in collaboration with two colleagues, F. N. Freeman and Karl Holzinger. A monograph on the whole study is now in press. In this particular study twenty pairs of identical twins separated in infancy and reared apart under differing environments were used. Many physical, intellectual and temperamental differences were determined by direct measurements and by tests. Full data on the life histories of the twin pairs were then rated by five judges independently, differences being rated on a scale from 1 to 10 points, for education, social and physical-health separately. The agreement was over 90 per cent. in all three categories and was considered as highly satisfactory. Then coefficients of correlation were determined for each of the measured differences and the various rated differences in environment. The majority of the coefficients were statistically non-significant, but a few were high and statistically valid. The most striking correlation was between amount of educational experience and amount of difference in scores of several intelligence tests. The least correlation existed between differences in social environment and differences in scores on several temperament-emotion tests. Differences in physical-health environment were strongly correlated with differences in weight, but not at all with height, head form and other physical differences. By determining the degree of correlation between measured differences in twins and the various environmental differences, it was possible to state approximately the shares of the different environmental factors in determining the observed differences in the whole set of twins.

The utilization of organic and inorganic iron in early infancy: HELEN OLDHAM and F. W. SCHLUTZ (introduced by A. J. Carlson). The iron retention of a normal infant was studied at three different levels of total iron intake. Each level was fed with varying proportions of inorganic iron. The organic iron of the diet appeared to be utilized as well as the inorganic iron.

Histology of the bone marrow in cobalt polycythemia: KATSUJI KATO (introduced by C. J. Herrick). In young rats first made anemic on an exclusive goat's milk diet polycythemia was produced by administration of iron and cobalt. Sections made from the mid-femur shows a marked hyperplasia of all the hemopoietic elements, especially of the myeloid series. The hyperplasia of the erythron consists mostly of normoblasts, although scattered throughout the marrow are also found many clusters of more primitive erythroblasts. The megakaryocytes also showed definite quantitative increase. The fat cells are reduced in number.

The influence of tension and relaxation on blood pressure: E. JACOBSON (introduced by A. J. Carlson).

Studies on the renal excretion ratio and reabsorption of urea in the dog: A. ALVING and W. GORDON (introduced by H. G. Wells).